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The Institute of Vitreous Enamellers

The Welsh Engineers' and Founders' Association

and

The Foundry Trades' Equipment and Supplies Association

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Mass Technological Training

The article we wrote a fortnight ago on "Apprentice Moulder Training" had just the effect we desired. It has stressed the incidence of the deficiency of the present system of primary mass education. This deficiency is due to the fact that all children are put through a standardised educational machine, and the object of our article was to guard against a similar occurrence with foundry technical education. It may sound strange, but in the large centres in Great Britain, for the last four decades, courses of lectures have been given in the evenings and on Saturday afternoons of such a character that those students who pursued them now occupy some of the highest positions in the industry. These classes had to be sought by the student in contradistinction to the modern efforts of the educational authorities seeking students for classes already established. The altruistic work done by Mr. Stott and tens of other enthusiasts is extremely praiseworthy, but there is still truth in the adage that "all work and no play makes Jack a dull boy." The mass technical training of apprentice moulders by the educational authorities is but a poor substitute for a proper works training in real craftsmanship. At the risk of repetition, we again emphasise that it is wise to provide technical training facilities of the highest order, and to encourage privately, and not by printed schemes, the attendance of those at all likely to benefit. Too many inducements are likely to react in the lowering of the general level of the classes, and to damp the enthusiasm of the more enlightened youth. Mr. Stott's statement in the JOURNAL last week, "Every boy leaving school at 14 should automatically proceed to evening classes," even though it be restricted to apprentice moulders, is one to which we most thoroughly object. Regimentation of this character will tend to lower the level both of the tuition at night schools and the product. Straight-line training of this character will produce a nation of mentally-atrophied technocrats. Apprentice moulders are now cursed with "benefits" of a standardised educational system, so surely they should not be condemned to continue along a path meeting with so little approbation as to warrant the endorsement of the remark by Mr. Stott that the "majority [are] definitely deficient in the three R's."

The B.C.I.R.A. Report

It will be generally conceded that the 16th annual Report to be presented to the general meeting of the British Cast Iron Research Association is a record of continuous and virile progress, and the results call for the warmest felicitations to the Council and staff. The income reached the figure of £16,400, the largest yet recorded; the staff has been augmented, and amongst recent extensions we note the acquisition of an experimental foundry. If the present rate of progress is maintained, the Council in two years time should be administering an income of some £20,000 a year, and will not only be able to maintain a progressive research programme, but to surround themselves with a group of specialists, whose experience will become deeper and more valuable with the passage of time. They will have a better informed opinion as to the major problems and difficulties which beset the industry, and the pure research worker will be able to direct his energies towards this solution. This action and reaction between what in the Report is called Research and Development is one of the most valuable features of the research association movement, but it calls for careful definition as to where the latter should stop.

In an appendix to the Report, under the heading of Moulding Sands and Refractories, there is a statement in connection with development which we deem to extend beyond the legitimate field of a research association. This reads "To assist members in the *choice*, mixture and treatment of moulding and core sands for jobbing or mechanised plants, in the establishment of sand control and in the *choice* and application of foundry refractories." We have italicised the word "choice," because herein lies the supreme danger. As there is no system such as is used in connection with Government departments which enables suppliers to advertise that their products are on the "War Office List"—an obvious impossibility in this connection—thus a position arises which enables a salesman to proclaim to customers that his line of refractories is the one being recommended by the research association. In refractories, as in most walks of life, what is one man's meat is another man's poison, and there is no universal "best"; but once it comes to the ears of a supplier that his material is the one chosen by the research association, he will obviously exploit the situation to the detriment of the status of the research association as well as antagonising firms whose material has been replaced by such choice. This criticism is put forward in the friendliest of spirit, as we feel sure that its import has not been fully realised by the Council.

C

"This Standardisation"

Mr. J. B. ALLAN'S ADDRESS TO SHEFFIELD FOUNDRYMEN

The opening meeting of the 1937-8 session of the Sheffield and District Branch of the Institute of British Foundrymen was held at the Royal Victoria Hotel, Sheffield.

MR. J. ROXBURGH, the retiring Branch-President, installed Mr. J. B. Allan, M.A., as his successor in the office, and said he was sure that Mr. Allan would receive the whole-hearted support of the Branch.

MR. ALLAN, after expressing his gratitude for the honour conferred on him, said he was looking forward to a successful year. An especially attractive programme of meetings had been arranged, and he hoped there would be good attendances at them all.

Proposing a vote of thanks to the retiring President, Mr. Allan said that the Branch had been singularly fortunate in the selection of their Presidents. They had not been satisfied in having men of local or even national reputation for the office, but had had at least two Presidents—one being Mr. Roxburgh—whose reputations were certainly international. It was difficult to follow in the chair a man with the qualities of Mr. Roxburgh.

MR. C. D. POLLARD seconded, and remarked that the Branch was not to lose Mr. Roxburgh's services in an official capacity, for he had been elected a delegate to the General Council.

MR. ROXBURGH, in reply, said he greatly appreciated the kind remarks made about him. If the members had enjoyed the last session as much as he did, he would feel very satisfied indeed. The primary object of their meetings was mutual instruction and education; at the same time, they also met as friends and acquaintances, and they had made some happy associations in this direction. He thanked the honorary secretary (Mr. T. R. Walker), the Council, and the general body of members for the way they had supported him during the past year.

Mr. Allan presented diplomas to Dr. C. J. Dadswell, Mr. T. R. Walker and Mr. F. Whitehouse for a joint Paper given by them last year on "The Manufacture of Iron and Steel Castings in Green Sand."

Mr. Allan then delivered his Presidential address, dealing with the subject of standarisation.

PRESIDENTIAL ADDRESS

Mr. Roxburgh and gentlemen, probably by nature of the event, and certainly by custom, the scope of a Presidential address can be, and generally is, a much broader one than that of a Paper. This does not mean that it is necessarily more interesting; it may be very much the reverse, but it does form a useful opportunity for reviewing the immediate or distant past, or speculating on the future, and perhaps suggesting some line of thought which may be worthy of consideration. Finally, there is every reason why it should be short

The title of my address is "This Standardisation," and not simply "Standardisation." The reason for the additional word is that, now that one can go to a motor dealer and purchase for one's car a spare part which will probably fit, there is a tendency to sit back and think that standardisation has been carried to the uttermost limit; yet I believe this to be far from the fact.

Before going any further, let me make it perfectly clear that I am no believer in "standard" houses, furniture, crockery or colour scheme—very far from it. If such were the case, life to my mind would be altogether unbearable. Again, I do not want to appear hypercritical and unappreciative of the great benefits that we enjoy to-day as a result of standardisation, which, in one form and another, has already been carried out.

Standardisation of Pipes

As a start, I propose to criticise to some extent my own business and, therefore, myself, and to give you some details of a bad example with which I am very familiar, in the hope that it will cause you to think of other examples more relative to your own businesses, and by thinking of them, that you will be enabled to take some steps towards the removal of a cause of endless expense.

I am concerned in the manufacture of cast-iron pipes, of the type known as pressure pipes, in contradistinction to rain-water goods and the like. The bulk of them are used for water and gas distribution. The tonnage of such pipes made in this country in the last year was approximately 500,000 tons—not at all a negligible figure; and the laymen who sees these pipes lying by the side of the roads all over the country might naturally be expected to believe that these were completely standard articles, and that any one of the same size would be likely to join up with any other.

It is true that a British Standard Specification exists for such pipes as are made by the vertically-cast method; in point of fact it has just been revised, and a new edition is due to be published within the next few months. This being so, it might also be expected that a gas or water engineer would only have to refer to this specification, state the sizes and pressure that were required, and all would be well. Unfortunately, this is far from the fact. To commence with, there are at least four recognised methods of manufacture used in this country at the present day: (1) The vertically-cast process; (2) green sand; (3) sand-spun, and (4) several varieties of metal spinning, and the British Standard Specification refers to one method of production only, *i.e.*, the vertically-cast method, which is, I believe, slowly dying because of the centrifugally-cast product.

As there are no British Standard Specifications covering the other methods, the purchaser has to accept those of the manufacturers. I do not believe he suffers greatly thereby; nevertheless, this means the first departure from a single standard of the cast-iron pipe. Because of the fact that there is some demand for all these types, those manufacturers who have plants for the centrifugal processes also maintain plants for one or other of the older ones, so that in these cases the majority of sizes, classes and types are duplicated.

As an example, in a range of sand-spun pipes of 4 to 24 in. diameter inclusive, but neglecting 11, 13, 17, 19 and 23 in., *i.e.*, 17 sizes in all, we at present hold 253 different stock items, and in the vertically-cast type, over 200, and as we also manufacture a range of small sizes by a metal-spun process, there are a further 105 different stock items, giving a total of approximately 560.

External Influences

It may well be asked why this is so. One reason is that, for every nominal pipe diameter, there are three pressure classes. One cannot find fault with that, because, on the face of it, a city situated amongst the hills, as Sheffield is, is likely to have to deal with a higher water pressure, than, for example, a city like York, which is situated on a plain. In any case, this fact means that the sizes are multiplied by three.

Again, some users, and nearly all water authorities, want coated pipes. The familiar Dr. Angus Smith's solution, despite its limitations, meets the requirements of most people, but when dealing with the gas authorities, some require coated pipes, others pipes coated on the outside only, and others no coating at all, and to the laymen it is somewhat difficult to understand why.

In addition to this, during recent years there has been an outburst of patent joints—mostly designed to overcome some objection to the old standard caulked lead one—such as flexible joints, to overcome breakages due to subsidence, or to increase the rate of laying.

In many cases the manufacturers have produced these in an endeavour to meet customers' special requirements, or merely as a new selling point. From these angles, their action is very praiseworthy, but from the viewpoint that I am now taking it is thoroughly reprehensible, for all these variants involve innumerable complications, such as vast ground area occupied by stock, instead of by remunerative plant; large sums of money laying idle; much increased handling charges; increased clerical work; large quantities of tools and equipment, much of which is only occasionally required; space for storing this equipment, and expense involved in its maintenance, to mention only a few.

I have hitherto dealt with straight pipes only, but the position is much worse when one considers bends, tees, branches and all such products known as special castings. The number of irregular and non-standard castings which are continually required is extraordinary, and it is certain that in numerous cases, a little study of the standards available would produce an equally good and certainly cheaper lay-out, and a much quicker delivery. In such cases reference by the user to the manufacturer would be of great value to the firm.

The tendency to say, "I know what I want and I intend to have it" is excellent up to a point, and it is true that a man who does not know what he wants is a handicap both to himself and to everyone else; but it is possible that while one may know what one wants, yet someone else may be able to offer a helpful suggestion as to how to get it possibly by a cheaper and quicker method.

Reverse Side of the Picture

If this be a true picture of what happens, or can happen, with a supposedly standard manufactured product, what can happen in a shop or a works manufacturing a non-standard product? I am thinking of the plant tackle, equipment, stores, etc., which are the tools used in the manufacture of our saleable products. I suggest that each of us should frequently spend some little time considering our stocks of tackle, spare parts and stores generally, with a view to seeing whether a reduction in the range cannot be made without a loss in efficiency.

These days of new plants and plant extensions provide great opportunities for limiting the varieties of plant which are installed. We must all be well aware of how plant manufacturers, in quoting for orders, will include a wide range of motor sizes in the laudable endeavour of making their quotations as low as possible. In almost every case that I know of, it has been possible greatly to reduce the number of sizes, admittedly in some cases by increasing costs; but there is no doubt of the ultimate economy, especially as frame sizes for given output conditions seldom remain standard for many years, and as plants grow so do the spares.

Again, in the purchase of machines, or any mechanical unit which has to be operated by individuals, it is well to bear in mind the advantages that accrue from having a limited number of types, especially from the point of ease of operation, when it becomes necessary to change operatives from one machine to another. Many of us are aware of the difficulties resulting from three- and four-speed gear-boxes in motor-cars, and the varying positions of the gear levers

for any one speed in different cars, to say nothing of varying positions of accelerator pedals; and a motor-car is often simple as compared with many manufacturing machines.

Over the past year or two my firm has ordered a considerable number of overhead cranes of various lifting capacities; in these, by compromise, many shafts, bearings, etc., and the quality of the materials used, have been standardised with the object of reducing spares, and obtaining the maximum degree of interchangeability. Similarly, motors and gears have been standardised as far as ever possible.

Of course, it is only possible to obtain the maximum advantages in such cases by giving something away, or in one word, by "compromise." In this world it is of no use expecting to get all we want, and it is just as well to realise that fact and arrange accordingly.

The Box Problem

I am aware that the examples given refer principally to new plants or plant extensions, but no foundryman is likely to be unaware of the desirability of limiting his range of box sizes, and it must always be a problem, which he must solve for himself. With large numbers off, special boxes accommodating the right amount of sand are obviously right. With the odd casting the solution is equally easy, but with numbers that lie between these extremes, individual circumstances must be the deciding factors. It must be pointed out, however, that unnecessary boxes represent money lying idle, both because of themselves and of the space they occupy, and therefore inefficiency. What number constitutes "unnecessary boxes" must be determined by the individual concerned.

Probably one of the commonest faults to avoid in the machine shop is the collection of a vast assortment of cutting tools; this is fatally easy. The makers of high-speed steels must be legion, and at the present rate of progress the word will apply to the makers of tungsten-carbide tools also.

Standardised Supplies

Most of these firms employ plausible and charming salesmen who, unless you are very wary, will persuade you "just to try" a product. Actually, I believe there is nothing to choose between a dozen or more makers, and the only thing to do is to carry out thorough experiments, and make the choice on the results, and, finally, stick to it through thick and thin, resisting such temptations as minor reductions in price. It will save much money and much time.

Oils suffer from the same trouble, both core oils and other types; they may even be worse than high-speed steels. You may have installed a new machine and a gear-box may be running slightly warm. At the psychological moment an oil salesman calls, and he is sure to have exactly the stuff which is required to overcome the trouble. Do not have it at any price. If it is thought that oil may have something to do with it, and it probably has not, telephone your ordinary supplier. He will be able to supply the necessary oil, if that has any bearing on the subject, and it will be as good as the other man's, and you will save yourself a lot of trouble thereby.

A case of this sort occurred when I was serving my apprenticeship; it was in the early days of the marine steam turbines, and bearings were one of the many troubles. In this case, some very special and expensive oil had been purchased in an effort to remedy a trouble, which was subsequently found to be due to a cause which had nothing to do with oil. A return was therefore made to the old brand, but nothing would persuade the shops that this latter was equal to the expensive brand. There were so many complaints that, finally, consignments of the standard brand, on arrival at the works, were put into the cask which had contained the expensive material, and after that there was no further trouble.

The object of all these remarks is this:—We enjoy almost numberless blessings as a result of the labours of those who have brought about the many standard specifications covering both dimensions and qualities, and as a result there is a great tendency to take these things for granted. We tend to think of standardisation only when it is applied to mass-production, and from one angle this is, of course, easy, because the latter is impossible without the former; but it is not necessary to have a set of conditions such as Henry Ford exemplified, when he said of his early mass-produced car that the buyer "could have any colour he liked, providing it was black."

It is quite possible to adopt some method of standardisation in a works, a shop or any one section of a shop, on any one or any number of articles, in respect of dimensions or physical qualities. Hence, I want to try and impress on you the great desirability of looking closely at the articles and materials we *use* in our shops—apart from those which we make; the latter are easier to bear in mind, and the former are apt to be overlooked. The cost of all this tackle has to be borne by the articles we sell, and all that is superfluous is a drag on the business.

If my words cause anyone to sit down and really consider the range of materials and tackle being used, I shall be well pleased, because I know that he will hit on something which will be a help in everyday work.

After a hearty vote of thanks had been accorded to the new President for his address, a smoking concert followed.

Notes from the Branches

Junior Section of the Lancashire Branch.—The annual meeting of the Lancashire Branch Junior Section of the Institute of British Foundrymen was held in Manchester on October 15. The chairman, Mr. A. Hopwood, explained that the annual meeting had been postponed from the end of the previous Session, and it had been found necessary to bring it to the first meeting of the new Session.

The retiring Council:—Mr. A. G. Adams, Mr. A. Flower, Mr. J. Hill, Mr. C. Jones, Mr. F. Royle, Mr. C. Sutcliffe, and Mr. Watts were re-elected. The Financial Statement was presented by the hon. treasurer, MR. A. BOYES, who pointed out that most of the apprentices and youths in the section had not yet paid their subscriptions. Unless an improvement was shown the section could not flourish. The major effort of the Committee for the past two or three years had been to struggle to make ends meet. As long as the whole interest of the Committee revolved round that, no advance could be made in either educational or social interest. If all the 82 members on the books paid, the section would be able to go forward without any worries, and he appealed to them to pay their subscriptions on January 1.

The CHAIRMAN said that the fact that the section had been able to carry on during the previous session without financial assistance from the senior Branch was a good sign, but they could do better. What would please him more than a good balance, even, would be to see a large attendance of youths and young men present at the meetings. The attendance was very poor last session, and he thought the average could be increased considerably.

The hon. treasurer, Mr. Boyes, and the hon. secretary, Mr. O. Bateson, to whom the chairman paid a warm tribute for their services, were re-elected unanimously.

The CHAIRMAN said that, as there was a vacant night in the programme in November, he proposed, instead of giving a Presidential Address, to take up the vacant evening himself, by speaking on the subject of "Why do boys and young men of the foundry neglect the advantages which the schools and educational authorities offer?"

Random Shots

To cast a pair of scissors with the legend "Made in Sheffield," actually part and parcel of the casting, is considered a clever bit of work. That is nothing beside the ambition of a certain gentleman who, in the late 18th century, took out a patent for the casting of needles!

"Mr. W. Bell, of Walsal," reads an old account of the needle-making trade, "has obtained a patent for the manufacture of needles of all sorts; the principal difference between which, and the usual method, is that the needles are cast, and, we suppose, that by this process needles may be made still cheaper than they now are."

* * *

Some inventions "catch on" and others don't, and this seems to have come in the latter category. One invention which did catch on, however, and has now become a machine of common usage in the foundry, is the moulding machine. How many daily users of the moulding machine know anything of its early history? About 90 years ago it was put on the map by Darling & Sellers, of Keighley, the Sellers of the business being, by the way, a grandparent of the captain of the Yorkshire cricket team. About the same time Clayton & Shuttleworth, Limited, of Lincoln, placed the stripping plate machine on the market. Very shortly after that, Messrs. Samuelson, of Banbury, produced a hand ram roll-over machine. Mr. Coleman brought over the first power machine from America some time prior to 1905, which he installed at Alfred Herbert's works at Coventry.

* * *

Every invention, too, has its enthusiasts, and every invention has the reverse. Even the well-established electric oven was condemned recently by one cook, who declared that it made the food taste of electricity!

* * *

On the other hand, the joys of electric light are sung in the following advertisement from India:—"You will want electric light. Newest invention. All who wish to enjoy business of modern city life at their smiling homes may purchase one. May be used on table or wall. You may light or blow it off lying in bed at any time by using the other end of the string that passes to your pillow. Very pleasing to reading and glorifies the room, and hall with splendid light as if sun has come down to your smiling house. Burns in strong wind. If placed in public functions, crowds will gather to it."

* * *

That great inventor Newton seems to be in danger of losing his place in the sun, for air pilots, at least, wish that he hadn't taken so much trouble over inventing the law of gravity. "Flying will never be safe," says one air-ace, "until the pilot can push a button and switch off the law of gravity."

* * *

Scotland is justly proud of the fact that it has never lost money on an exhibition yet, thereby proving the truth of the old adage, "Look after the threepenny bits and the pounds will look after themselves"!

* * *

A surprising fact, revealed by a recent comparison of figures, is that the London Midland & Scottish Railway employ 25,000 more men than the whole of the British regular army. As, however, the combined efforts of all the British railways last year managed to shift 31 million tons of the raw materials used by, and the products of, the iron and steel industry, perhaps that fact is not so surprising after all.

"MARKSMAN."

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Copper in Cast Iron and Malleable Iron*

By W. B. SALLITT

I.—CAST IRON

During the last decade, ironfoundry technique has developed very rapidly, both in respect of moulding and melting practice, and much experience has been gained regarding the effect of alloy additions upon the properties of cast iron. As a result, cast irons of greatly improved strength and uniformity have been developed. In the past engineers have regarded cast iron with a certain amount of suspicion, but in the face of these improvements their attitude has been modified considerably and the field of application of cast iron has, in consequence, been greatly extended. The use of alloy cast irons for such highly stressed parts as automobile crankshafts, camshafts and valve push-rods may be quoted as typical examples. It is significant of the changing attitude of the engineer towards cast iron that the Institution of Mechanical Engineers is now sponsoring a comprehensive research into the properties of a wide range of alloy cast irons.

Copper has played no small part in this "renaissance" in the foundry: for example, the first cast crankshafts to be put into production contained 2 per cent. copper, and the first camshafts 3 per cent. As the work of research has proceeded, new properties of copper as an alloying element have been revealed, which are now being put to practical use in the foundry.

Although the use of copper additions in cast iron are of comparatively recent development, it is interesting to find that about 100 years ago, in the Birmingham district, it was the practice to add a couple of "Boulton pennies" to a handshank of malleable iron when specially good metal was required. These "Boulton pennies" weighed about 2 ozs. and contained over 97 per cent. copper.

Copper Additions

Copper is very easily alloyed with cast iron. As it is less prone to oxidation than any of the common alloying elements, full credit may be given for the copper content of back scrap and no allowance for oxidation need be made in calculating additions. Although its melting point is relatively high (1,083 deg. C.), copper goes into solution very readily, particularly as its density is greater than that of molten iron. Additions of up to 3 per cent. may be added to the ladle, but copper may be also introduced as part of the charge in cupola or other furnace practice, although in the latter instance it is usual to make additions just before tapping. Scrap copper in any size or shape is suitable for furnace additions, provided that it is reasonably free from impurities; for ladle additions, copper shot, *i.e.*, granulated copper, copper wire, turnings or small pieces of scrap such as fire-box stay bolts, cut into lengths of about 3 in., are suitable. The ladle should be well stirred before pouring.

Cost

Cost is an important factor where alloy irons are concerned. Table I shows the cost (per ton of metal melted) of a 1 per cent. addition of the more common alloys. It will be seen that the cost of copper is of the same order as that of the cheaper alloys such as chromium and manganese.

Influence of Copper on Structure of Cast Iron

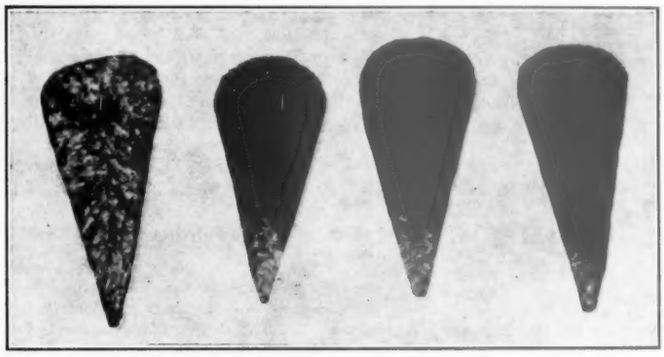
The useful limit of copper additions in ordinary cast iron is about 3½ per cent. Up to this percentage the influence of copper on the structure of cast iron resembles that of nickel: it acts as a graphitiser, and refines graphite, and secondly it hardens and strengthens the matrix. The graphitising action of copper is illustrated in Fig. 1, which shows four chill bars poured from the same heat and having the same composition except for copper content. Chill is progressively reduced as copper is added, indicating that in so far as chill is concerned, copper behaves in a similar manner to silicon. There are, however, two very important differences between copper and silicon; the first is that silicon coarsens graphite, *i.e.*, causes open grain, whereas copper refines graphite, and thus closes up the grain. This difference has a very material bearing on mechanical properties, because cast iron invariably fractures along the graphite flakes and therefore its strength is largely dependent on the graphite size and shape.

The second difference is that if, to a casting with varying sectional thickness, silicon is added to reduce chill in thin sections, the structure of thicker sections also becomes softer and coarser, because the combined carbon content in these sections is also reduced and free ferrite is formed. Copper, on the other hand, does not cause pearlitic carbide to break down to ferrite, and so, far from softening the matrix in thicker sections, it actually hardens, toughens and strengthens it, at the same time as it is removing chill from thin sections.

The matrix of cast iron is very similar to that of pearlitic cast steel, and the effect of 2.5 per cent. copper on such a steel is to increase the tensile strength by as much as 16 tons per sq. in. The effect on the cast-iron matrix is similar, though the improvement in strength of the iron as a whole is, of course, less marked, since it is largely dependent on the condition of the graphite. These essential differences between copper and silicon are illustrated in Figs. 2 to 5. Fig. 2 shows the effect of increasing the copper content in step-bar castings: chill is progressively reduced in the thinner sections, but in the thicker 1-in. sections, once the free carbides have been broken down, the hardness increases as copper is added. Figs. 3 and 4 show that additions of silicon to an iron of approximately "cylinder" composition causes open grain and even shrinkage defects at changes of section, whilst copper additions tend to close up the grain. The hardness figures on the step-bars shown in Figs. 3 and 4 are plotted in Fig. 5. It will be noticed that copper tends to render the hardness more uniform in the thick and thin sections, whilst there is considerable "scatter" in the bars containing silicon additions.

Figs. 2 to 5 illustrate very clearly the value of copper for castings having thin and thick sections, such as cylinder blocks, heads and liners. For castings of this type, composition has to be maintained within accurate limits if hard spots on the one hand, or sponginess on the other, are to be avoided. Clearly, if trouble be experienced with hard spots in thin sections, copper may safely be added without risk of increasing the tendency towards sponginess in thick sections; and further, by making still larger additions of copper and simultaneously reducing the silicon content, an iron may be obtained the structure of which will be much less sensitive to small changes in composition.

It is also found that when copper is added in substitution for silicon, the variation of chill



T.C (per cent.)	3.23	3.13	3.13	3.09
Si (per cent.)	1.25	—	—	1.17
Mn (per cent.)	0.54	—	—	0.46
P (per cent.)	0.33	—	—	0.32
Cu (per cent.)	0.00	0.82	1.78	2.43

FIG. 1.—CHILL BARS SHOWING PROGRESSIVE REDUCTION OF CHILL WITH INCREASING COPPER ADDITION. SCALE APPROXIMATELY ½ FULL SIZE (B.C.I.R.A.).

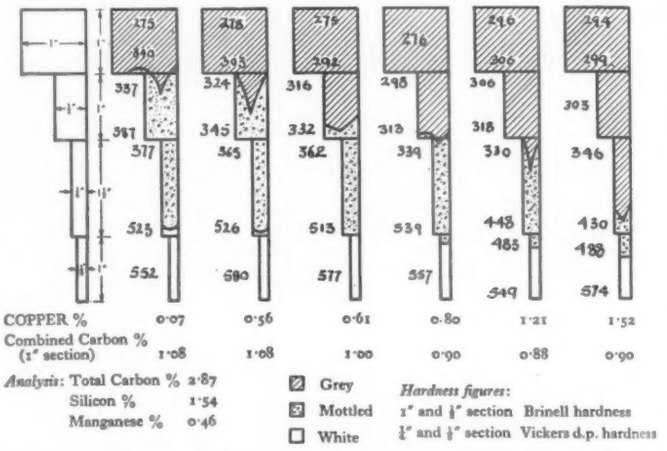


FIG. 2.—STEP-BAR CASTINGS WITH INCREASING PERCENTAGES OF COPPER. (BY COURTESY OF SIR W. G. ARMSTRONG-WHITWORTH & COMPANY, LIMITED.)

TABLE I.—*Cost of 1 per cent. Addition of Alloys.*

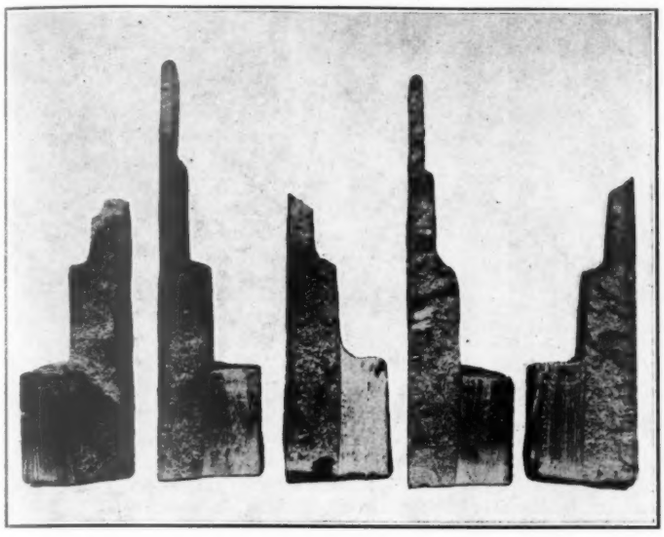
Alloy.	Method of adding.	Cost of 1 per cent. addition per ton of metal melted.
		s. d.
Manganese ..	Ferro-manganese ..	5 0
Chromium ..	Ferro-chrome ..	6 11
Copper	Light scrap copper ..	9 7
Nickel	Nickel "F" shot ..	35 0
Molybdenum ..	Ferro-molybdenum	106 0

* Paper read before the West Riding of Yorkshire Branch of the Institute of British Foundrymen, Mr. H. Forrest presiding.

during a day's run from the cupola can be controlled within much narrower limits. The Ford Motor Company use no less than 3 per cent. copper in their cast camshafts, in which the silicon content is reduced to 0.5 per cent. For these castings, no artificial chills are used, but the composition is controlled so accurately that the cam-tips chill white by virtue of their comparatively thin section, whilst the bearings are grey and machinable. The high copper content is found to maintain the depth of chill within very narrow limits during the day's run.

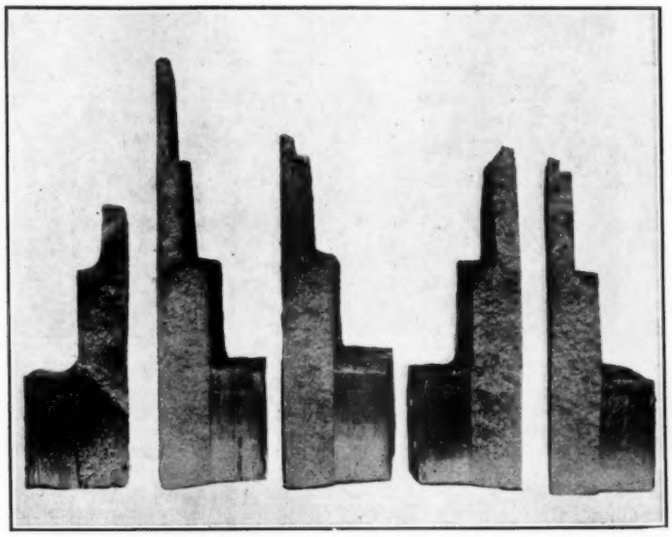
If the copper content in cast iron exceeds about 5 per cent., globules of copper appear in the structure, which (as will be noticed in Fig. 9) nearly always contain particles of slag. Norbury has suggested that slag particles, which are solid at the temperature at which the eutectic freezes, form the nuclei upon which primary graphite separates, and that if such particles have been removed, as, for example, by superheating, or have been coated with a low melting-point film, which is liquid at the eutectic temperature, no primary graphite is formed and the iron supercools, the graphite which separates at lower temperatures being completely refined. In irons containing copper in excess of the liquid solubility limit, the free copper is found to precipitate round any solid inclusions in the melt, and since the melting point of the copper-rich constituent (1,094 deg. C.) is lower than that at which the cast-iron eutectic freezes, the solid inclusions become in effect liquid, and do not therefore appear to provide nuclei for the separation of coarse primary graphite; consequently, the graphite, which separates at lower temperatures, is in a very fine state of division, as is shown in Fig. 9. For purposes of comparison, normal graphite, such as would have been formed in the absence of primary copper, is shown in Fig. 10. If the suppression of primary graphite is to be complete, the copper content must be somewhat in excess of the molten solubility limit, *i.e.*, 6 to 8 per cent., in order that all the slag inclusions in the melt may become coated with copper.

Pearce has suggested that for castings such as ingot moulds, which must offer resistance to thermal shock and growth, cast irons should preferably have a high carbon content with a very



	No. 1	No. 2	No. 3	No. 4	No. 5
T.C ..	3.20	3.18	3.24	3.18	3.24
Si ..	2.02	2.13	2.21	2.32	2.44
Cu ..	0.04	0.04	0.04	0.04	0.04

Fig. 3.—Effect of Silicon Additions to Cylinder Iron. In each case the Mn is 0.55 per cent. and P and S low.



	No. 1	No. 6	No. 7	No. 8	No. 9
T.C ..	3.20	3.22	3.20	3.18	3.18
Si ..	2.02	2.09	2.06	2.03	2.06
Cu ..	0.04	0.55	1.03	1.58	1.69

Fig. 4.—Effect of Copper Additions to Cylinder Iron. In each case the Mn is 0.55 per cent. and P and S low.

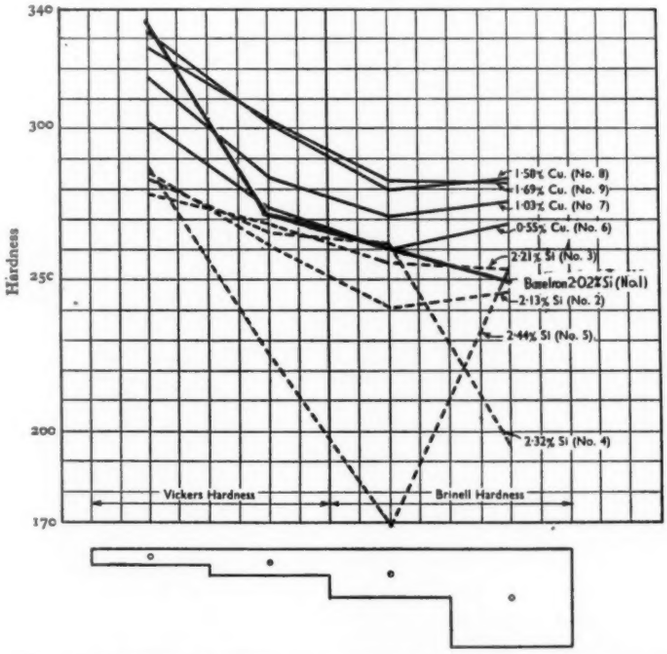


Fig. 5.—Hardness Figures on Step-bar Castings shown in Figs. 3 and 4. Note Uniformity of Hardness of Copper Bars and Increase in Hardness in Thick Sections due to Copper.

Fig. 6.—Fracture of Ford V-8 Cast Camshaft. (By Courtesy of Ford Motor Company.)

The fracture of the Ford camshaft is shown in Fig. 6, whilst the microstructure of the cam-tip and core is shown in Figs. 7 and 8 respectively.

fine graphite structure, since the high carbon content will confer resistance to thermal shock, whilst the fine graphite will prevent the entry of oxidising gases and thus delay growth. Such a combination has in the past been difficult, if not impossible to achieve, because the effect of raising the carbon content is to coarsen the graphite. Refinement by means of primary copper, however, may provide a solution of this difficulty.

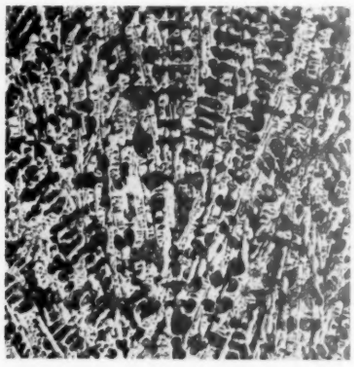


Fig. 7.—Microstructure of Cam-Tip of V-8 Cast Camshaft. Etched 5 per cent. Nital. × 100. (By Courtesy of Ford Motor Company.)

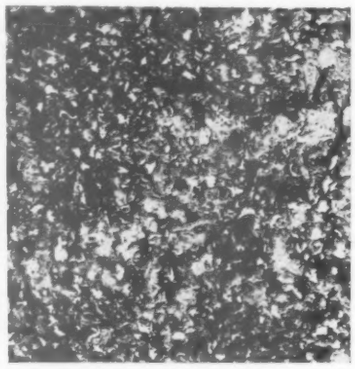


Fig. 8.—Microstructure of Core of V-8 Cast Camshaft. Etched 5 per cent. Nital. × 100. (By Courtesy of Ford Motor Company.)

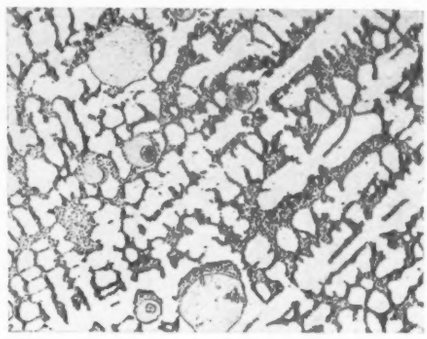


Fig. 9.—Microstructure of Cast Iron showing Graphite Refinement produced by Primary Copper. Unetched. × 50. (B.C.I.R.A.)

Balanced Alloy Additions in Cast Iron

Since copper is a graphitiser, it may be usefully added in conjunction with hardeners such as manganese, chromium and molybdenum.

Table II.—*Graphitising Value of Elements.*

Element.	Graphitising value.
Silicon	+ 1.0
Copper—	
Carbon over 3.0 per cent.	+ 0.30
Carbon below 3.0 per cent.	+ 0.20
Nickel	+ 0.35
Manganese	− 0.25
Molybdenum	− 0.35*
Chromium	− 1.20

* This value should be accepted with caution, as under certain conditions molybdenum appears to exert little or no influence on chill.

These three elements can produce very material improvements in the strength of cast iron, but from the point of view of chill they act in an opposite manner to silicon, *i.e.*, they increase chill. Therefore, if one of these alloys be added to cast iron, a balanced percentage of a graphitiser must also be added, or the iron will become brittle and unmachinable. The disadvantage of silicon has already been stressed; it coarsens the grain and therefore prejudices the improvement in properties resulting from the hardening alloy. Copper, on the other hand, contributes to this improvement. Table II shows the graphitising value of the more common elements. It will be seen that, for a balanced addition, copper and manganese or copper and molybdenum should be added in approximately equal proportions, whilst the copper-chromium ratio should be about 4:1.

Fig. 10.—Microstructure of Cast Iron showing Normal Graphite. Unetched. × 50. (B.C.I.R.A.)

Influence of Copper on Mechanical Properties of Grey Iron

Simple Copper Additions. — As is shown in Fig. 11, no very striking improvement in the properties of cast iron results from a simple addition of copper. It will be seen that compressive strength, tensile strength and Brinell hardness increase progressively as copper is added. This increase in Brinell hardness is not accompanied by any appreciable reduction in machinability, such as would result from a similar increase in hardness produced by raising the combined carbon content.

A curious feature of either copper or nickel additions to cast iron is that the transverse strength is increased progressively in irons having a Brinell hardness of under 200, but in harder irons there is usually an improvement only with the first addition, and thereafter a slight falling-off. In view of the simultaneous increase in both tensile and compressive strength, this falling-off in transverse strength may perhaps be regarded as a peculiarity rather of the test than of the properties of the iron.

It has been shown experimentally that additions of copper alone, or nickel alone, or copper plus nickel up to a total alloy content of 3 per cent., have a very similar effect on mechanical strength.

The toughness of cast iron, as judged by the repeated impact test, is considerably improved by additions of up to 1½ per cent. copper, as is shown by the following data obtained on inoculated cast iron containing 3.0 per cent. carbon, 1.50 per cent. silicon, 0.80 per cent. manganese, 0.106 per cent. phosphorus and 0.102 per cent. sulphur.

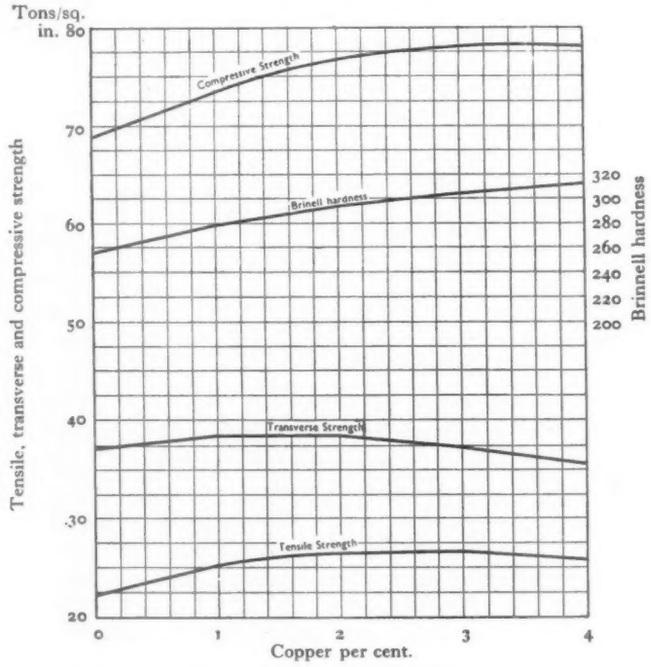


Fig. 11.—Effect of Copper Additions on Mechanical Properties of Grey Cast Iron (Eastwood, Bousu and Eddy).

	1	2	3
Copper, per cent. ..	—	1.02	1.60
Repeated impact blows to fracture	1,277	2,851	3,372

The improvement in toughness resulting from copper additions is also noticeable in white-iron castings which are being increasingly used even for highly stressed and moving parts, an example of which is the Ford die-cast valve push-rod shown in Fig. 12.

These valve push-rods are chill-cast hollow in permanent moulds with a sand core, and are heat-treated to remove casting strains and to soften the matrix, but are not heated hot enough nor long enough to make the iron grey, as white iron is essential to give wear resistance. This iron is very low in silicon and contains 0.75 to 1.0 per cent. copper; the action of the copper is to confer on the pearlitic matrix the necessary toughness to counteract the inherent brittleness of the undecomposed cementite in the chilled iron.

Balanced Additions

A striking improvement in the properties of grey iron arises from the replacement of silicon by copper or from balanced additions of copper with manganese, chromium or molybdenum.

Table III gives typical examples of such additions. The properties of the first pair of irons illustrate the improvement obtainable by replacing silicon by copper, while the second and third pairs show the effect of balanced additions of copper and manganese, and copper and chromium respectively. In the last group, the first two irons show the improvement in properties obtainable in an iron containing ½ per cent. molybdenum by the addition of about 1½ per cent. copper, whilst a comparison between the first and third irons in this group again emphasises in a striking way the effect of replacing silicon by copper.

TABLE III.—*Effect of Balanced Alloy Additions to Cast Iron.*

Composition, per cent.						Tensile strength. Tons per sq. in.	Modulus of rupture. Tons per sq. in.	Brinell hardness.
C	Si	Mn	Cu	Cr	Mo			
2.95	2.26	0.70	0.30	—	—	18.8	30.6	248
2.85	1.61	0.53	1.90	—	—	27.8	44.3	299
3.10	1.63	0.48	0.16	—	—	—	31.0	225
3.08	1.52	1.10	2.20	—	—	—	38.2	233
3.21	2.39	0.61	—	—	—	—	27.0	188
3.21	2.35	0.71	1.92	0.45	—	—	32.0	240
2.99	2.25	0.61	—	—	0.51	17.0	31.8	207
2.99	2.25	0.61	1.66	—	0.51	21.0	34.2	255
2.92	1.61	0.64	1.23	—	0.47	26.1	46.7	259

FIG. 12.—DIE-CAST VALVE PUSH-ROD, HAVING ANALYSIS: T.C, 3.65-3.90; SI, 0.30-0.65; MN, 0.15-0.50; CU, 0.75-1.0; P, 0.05 (MAX.), AND S, 0.08 (MAX.) PER CENT.

(*Continued at foot of next column.*)

High-nickel austenitic cast irons such as "Ni-Resist" usually contain about 7 per cent. copper. Such irons offer a marked resistance to almost all types of corrosive media and are practically immune from growth at elevated temperatures. They are also widely used for plant handling liquids containing abrasive solids, *e.g.*, sand in suspension, owing to their surface work-hardening properties.

(*To be concluded.*)

British Cast Iron Research Association

EXTRACTS FROM ANNUAL REPORT

The 17th annual meeting of the Association is being held to-day (Thursday) at the Hotel Victoria, London. The 16th annual report will be presented, of which the following is an abstract.

The present report covers the progress and general activities of the Association for the year ending June 30, 1937. The statement of accounts shows that the income has been the highest yet reached in its history. In the Annual Report for 1933-34 a chart was given showing the growth of industrial income and total income (industrial income plus grant) up to that date. The succeeding year opened a new five-year period with respect to grant from the Department of Scientific and Industrial Research and the chart was extended to indicate the income the Council hoped to reach for each year of this period, on the assumption that the Association would be able to take advantage of the grant offer. Income has followed the prediction fairly closely, although in actual fact the increase in grant-earning income has been less and the increase in non-grant-earning income has been greater than that estimated. The Council cordially invite all interested firms, institutions and persons to support the Association, in the confident belief that an annual expenditure of the order of £15,000 can scarcely fail to benefit every member, and that the Association is performing an essential and increasingly valuable service to the industry in providing the machinery for the exercise of mutual co-operation within it.

Council and Officers

Annual Meeting.—The sixteenth annual general meeting was held in London on November 5, 1936, the retiring President, Major F. A. Freeth, O.B.E., D.Sc., F.R.S., being in the chair. The Rt. Hon. the Earl of Dudley, M.C., was unanimously elected President, and the Council express their gratification at the interest which prompted his acceptance of their invitation.

Officers.—Early in the year Mr. H. B. Weeks, F.I.C., intimated that he thought the time had arrived for the Council to appoint a successor to himself as chairman. At the same time, Mr. J. T. Goodwin, M.B.E., expressed his desire to be relieved of his office of vice-chairman, which he had held for some twelve years. The Council reluctantly agreed to their wishes, and take this opportunity of expressing the warmest thanks of the Association to them for their devoted services. Mr. Weeks was the first chairman of council and held this office continuously for a period of fifteen years. During this time he was never absent from a council meeting. Mr. Goodwin has during his period of office assiduously discharged the duties which normally fall to an honorary treasurer. The Council are gratified that both gentlemen are able to continue as members of Council and to place their experience at the disposal of the Association. The Council unanimously elected Dr. Harold Hartley, who has been Chairman of the Research Committee for some time, as its chairman. The Council also decided that a small group of vice-chairmen should be appointed from the principal sections of the industry represented in the Association. Two elections have been made to this office, those of Mr. P. A. Abernethy, of Colvilles, Limited, Glasgow, and Mr. J. B. Allan, M.A., of the Staveley Coal & Iron Company, Limited, Chesterfield. Both these gentlemen have actively served on the Council or committees. During the year five Council meetings have been held, in Birmingham and London.

Committees.—Mr. J. E. Hurst was unanimously elected to succeed Dr. Hartley as chairman of the Research Committee, of which five meetings have been held during the year. Eight sub-committees, which deal with the detailed work of the Research Committee, have during the year held twenty-two meetings, and eight meetings of various panels arising therefrom have also been held. Mr. T. M. Herbert, M.A., was re-elected chairman of the Publications Committee, which held three meetings. One meeting of the Education Committee, of which Mr. E. R. Briggs, M.Inst.C.E., is chairman, has also taken place. The Council take this opportunity of thanking all those gentlemen who so freely give their time and experience at these meetings.

The Council profoundly regret to learn of the death of Sir John Dewrance, G.B.E., who was President of the Association for the period 1924-27, and who will long be remembered for his active and disinterested advocacy of the value of scientific research to industry. Science also has suffered a severe blow in the recent death of Lord Rutherford of Nelson, O.M., F.R.S. Known to the Council's officers as chairman of the Advisory Council to the Department of Scientific and Industrial Research, Lord Rutherford opened the Association's laboratory extensions on July 6, 1932, and his genial and approachable personality will be remembered no less than the brilliance of the research in physics which put the British school in the front rank and made the Cavendish Laboratory at Cambridge a Mecca for students from all over the world. It will be recalled that, on the occasion in question, Lord Rutherford expressed the view that the Association should aim at an income of £40,000 per annum in order adequately to discharge its responsibilities to the industry.

Research and Development

Grey Iron and Nickel and Alloy Cast Iron Sub-Committees.—The work reported last year on graphite refinement, by means of which the highest possible degree of graphite refinement is secured, has been followed along several lines. Attempts have been made to apply the process to the cupola furnace, for which purpose a small experimental cupola was built. This problem has proved to be extremely difficult, and the conditions leading to refinement from the cupola are not yet fully established, although definite progress has been made. In view of the strong theoretical possibility referred to in the last report that the change is associated with the presence in the melt of non-metallic inclusions, considerable work has been done on the separation and analysis of inclusions in both pig-iron

and cast iron. The first separation method adopted was the alcoholic iodine method recommended by the Oxygen Panel of the Iron and Steel Institute's Ingot Committee. In addition, the apparatus for the chlorine method has been set up. In view of its difficulty and delicacy, this work is being carried out in close conjunction with other laboratories in the country, working on the same problem, through the Oxygen Panel, and attention is being given to inclusions in basic irons for the Blast Furnace Committee of the Iron and Steel Industrial Research Council. Application of the process to the production of ingot moulds for steel ingot has also been made on a works scale at three steelworks, the results of which are now under examination. The question of graphite refinement has been found to influence, directly or indirectly, the work and interests of practically every sub-committee in the Association, and during the year a meeting of chairmen resolved itself into a Graphite Panel, which has held three meetings to ensure fullest discussion and applications of the process. Practical works application of the process to crucible melted irons and irons from certain other furnaces is being made.

Work on the shrinkage and contraction of cast iron has been pursued actively throughout the year, and its first stage is now practically completed.

The work on aluminium cast irons, begun last year, has been continued, and it is now practicable to produce sound cast irons, containing aluminium, of good mechanical properties and showing such resistance to heat at elevated temperatures as to justify extended trials where resistance to heat is required. The successful manufacture of sound castings now makes it possible to determine the properties of a range of aluminium irons. The aluminium cast irons appear to have unusually high strength at elevated temperatures.

During the year the Association undertook, at the request of the Institution of Mechanical Engineers, an important investigation on high-duty irons, planned in the first place to cover two years. This work follows logically from the Association's earlier work on inoculated irons, on irons containing additions of nickel, molybdenum and copper, and on the preliminary work carried out on heat-treatment, followed by the work carried out at the N.P.L. on combined stress and on crankshaft irons and steels. It is proposed to examine a complete range of irons of 1.5 per cent. carbon upwards, both plain and alloyed, and heat-treated where this is necessary to secure the best properties. It is intended to establish the whole of the mechanical properties and data required for the use of such irons in engineering applications, and arrangements have been made for special mechanical tests to be carried out by Dr. H. J. Gough in the Engineering Department of the N.P.L.

Melting Practice and Sands and Refractories Sub-Committees.—The work continued from last year in conjunction with the L.M.S. Railway Company on the foundry and laboratory characteristics of a series of cupola cokes has been completed, and the results were embodied in a report by Dr. H. O'Neill, of the L.M.S. Railway Company, and the Director, to the June Conference of the Institute of British Foundrymen at Derby. Some preliminary work has been done on the influence of tuyere size, blast pressure and volume on cupola melting efficiency.

The development of the balanced-blast cupola has been continued. The total number of installations made or under construction is now 175, with an aggregate hourly capacity in excess of 1,200 tons. Fifty installations have now been made or are being made overseas. The average size installed has a capacity of seven tons per hour, but they range from furnaces of 21-in. diameter, yielding 1.8 tons per hour, to 66-in. diameter, yielding 17.8 tons per hour. A furnace of 81-in. bore is under construction in U.S.A., with a rated capacity of 26.8 tons per hour, and furnaces up to 90-in. bore can be designed. The fuel saving effected by these installations, apart from other advantages, may be conservatively estimated at £25,000 per annum. Although the statistical data available does not permit a reasonably accurate estimate, there is ground for believing that one-fifth to one-fourth of the cast iron now made in Great Britain is melted in the balanced-blast type of cupola, and includes both light and heavy castings, malleable cast iron, refined pig-iron, and the melting metal for steel castings in the converter.

During the year Mr. W. Y. Buchanan addressed the Melting Practice Sub-Committee on the melting of borings and turnings in the cupola and the possibilities of extending the application of his proposals are being explored. The Rotary Furnace Panel of this sub-committee continues active.

An important investigation on the use of naturally occurring clays as bonds for moulding sands, both natural and synthetic, has been completed and reported to members. The examination of refractory linings of cupola and rotary furnaces in relation to service life has been continued, and work is also being carried out reviewing methods of testing moulding sands. The work begun by the Association over ten years ago on sand testing and control has been amply justified in view of the necessity for the close control of moulding sand in the mechanised and continuous production plants now being so widely adopted in the industry.

Other Sub-Committees.—The Tests and Specifications Sub-Committee has been concerned with various methods for improvements in accuracy and speed of analytical methods. The Association has also actively co-operated with the British Standards Institution in the revision of Specification 321/1928 for grey-iron castings and the formulation of a new specification for high-duty irons.

Following the revision of recommended analytical tolerances for foundry pig-irons, the Pig-Iron Sub-Committee has been engaged on a scheme for the grading of pig-iron, now approaching completion. In this work the committee has had the active co-operation of members nominated by the various manufacturers' associations in the blast-furnace industry.

The White and Chilled and Malleable Cast Iron Sub-Committees have also been active, and reports of their deliberations have been made available to members.

Following two meetings of members interested in the vitreous enamelling of cast iron, two Enamelling Panels were formed, one for Scottish and the other for English members, and discussions have taken place on the lines on which investigation could be most profitably pursued. The work on graphite refinement and on clay-bonded synthetic sands is of special interest to those engaged in vitreous enamelling, and a number of practical problems have also been dealt with. Further informal discussions have taken place with representatives of The Institute of Vitreous Enamellers, who are also keenly interested in this subject, and it is hoped that co-operation will be established. It is therefore proposed to provide a full-time investigator for vitreous enamelling, and to provide proper laboratory resources for tests on vitreous enamelled ware and materials used for manufacture.

Development Department.—During the year the Development Department, which assists members in dealing with practical and technical matters and advises on prospective developments, dealt with 1,217 inquiries, an increase of 77 over the previous year. The number of visits paid to members by the staff has also increased.

Headquarters Laboratories.—The various laboratories are called upon to make estimations and tests both in connection with the research programme and arising from the advisory and development work carried out by the development department. The chemical laboratory carried out over 5,000 duplicate estimations and the metallographic laboratory made nearly 1,000 micro-examinations. In the mechanical-testing laboratory 2,300 mechanical tests of various kinds were made. In the sands laboratory 1,900 tests on sands and refractories were made for strength, permeability and mechanical analysis. In the melting shop 290 melts, crucible and cupola, were carried out.

Scottish Laboratory.—The Scottish Laboratory has functioned normally during the year with Mr. H. Cowan, B.Sc., as superintendent, and one assistant. It has been fully engaged on inquiries, problems and visits.

Publications Committee

Library and Information Bureau.—The library received 665 accessions during the year, and the total number of loans slightly exceeded 2,000, excluding lantern slides. About 300 inquiries from members were dealt with exclusively by the library and information bureau.

Exhibitions.—On two occasions during the year the Association co-operated in a joint exhibit of the work of the country's research institutions, organised by the Department of Scientific and Industrial Research. The first occasion was the exhibition held at the Building Centre in London in March, 1937, and the second that of the Engineering and Marine Exhibition in London in September, 1937.

Papers and Lectures.—The Director lectured during the year to the North-Eastern Branch of the Institution of Mechanical Engineers, to the Midland Metallurgical Societies, to the Birmingham Branch of the Institute of British Foundrymen, and to the Board of Education's Engineering Summer School at Oxford. Reference has been made above to a Paper with Dr. H. O'Neill on cupola cokes. Other Papers have been given during the year by Dr. A. L. Norbury and Mr. L. W. Bolton. The Director contributed to a discussion on Research and the Motor Vehicle convened by the Institution of Automobile Engineers, opened the discussion on an important Paper to the same body by Dr. Gough and Mr. Pollard of the N.P.L. on "Properties of Some Materials for Cast Crankshafts," and contributed a short Paper on the wear of cast iron to the discussion organised by the Institution of Mechanical Engineers on Lubrication and Lubricants.

Study Course.—The arrangement of a three-day study course has now become a regular event in alternate years, and the next course is planned for November 10 to 12, 1937, full details of which have been sent to members in the United Kingdom.

Finance and Membership

Accounts.—The accounts circulated to members with this report show a total income for the year of £16,405, and a credit balance on the year's working of £1,494. The subscriptions qualifying for grant enabled a grant of £5,750 to be earned, out of a possible grant under the present arrangement of £8,500.

Membership.—At the close of the year the number of ordinary and trade members was 332, and of associate members 53.

Accommodation

Future Developments.—The Association has for some years had limited resources for the production of small castings and test-bars, and no department has shown greater need for growth than the melting shop. It is called upon to produce test-bars and castings for the research programme and, to some extent, trial castings for development. The limited area available for this work has now become inadequate, and during the year the Council acquired a new shop adjacent to the headquarters laboratory, having an area of 2,500 sq. ft. This is being equipped with the necessary furnaces, sand mill, etc., for producing experimental castings and test-bars.

Vitreous Enamelling Section

Stannic Oxide as an Opacifier in Wet Enamels*

By Dr.-Ing. L. STUCKERT

(ABSTRACT)

In an earlier work the author has shown that different opacifiers exert a more or less favourable influence on diverse properties of two enamels, when these opacifiers are used only as mill additions. It was intended to investigate whether the results previously obtained with only two enamels are of general significance at least in their broad features; for the range of enamels is so wide, and their composition so variable, that it is unsafe to generalise on results obtained for only two enamels. It is shown in this investigation that the regularities previously found are valid for most enamels. It was necessary also to examine many other aspects of the behaviour of the enamels, to avoid the error of ascribing all the observed effects to the influence of the opacifying agent. The most outstanding phenomenon in the previous study was the retardation effect in the production of turbidity, which is shown from many viewpoints in the present investigation. The whole work has undergone a certain widening of scope, since it now includes also a discussion of these phenomena. It is, in general, possible to explain the phenomena shown by the different enamels, and to trace certain regularities.

This work shows in a wide range of enamels, belonging to different groups, that stannic oxide, as a mill-addition only, exerts in all cases a favourable effect on the properties of the enamel. These experiments are, however, not merely informative as individual results; it is also possible to fix the limits of this favourable influence, and to recognise certain regularities in its increase and decrease within the individual series of enamels. The observed phenomena and the quantitative data obtained lead to conclusions as to the nature of the processes occurring during firing.

The work was limited to the alteration of properties effected by the opacifier—in all cases tin-oxide—impact-strength, thermal resistance, chemical resistance, opacity and gloss. Only the influence of tin oxide on the chemical resistance, opacity and lustre of thirty enamels will be described in detail, and a new apparatus for the determination of impact strength will be mentioned briefly as well as a new method of measuring this property. The influence of stannic oxide on the thermal strength may be summarised as favourable in most cases, with exception of several enamels rich in fluorides, especially in cryolite. From the results obtained for opacity and gloss, an attempt has been made in the second part of the work to define the field of enamels particularly suitable for the opacifier tin oxide. In this part, the rate of development of opacity will also be described.

As initial melt for the first part an enamel with medium pre-opacification was selected. The composition is given under Enamel 7 in Table Ia of the Paper. Six series of enamels were dealt with in the following manner:—

Series.		Table No.
1	Exchange of SiO_2 for B_2O_3	Ia
2	,, ,, ,, ,, Al_2O_3	Ib
3	,, ,, ,, ,, KNaO	Ic
4	,, ,, K_2O ,, Na_2O, keeping the SiO_2 content constant	Id
5	Exchange of SiO_2 for CaF_2	Ie
6	,, ,, ,, ,, Na_3AlF_6	If

Influence of the Opacifier on Impact Strength

For the determination an apparatus was used giving a single blow sufficiently hard to exceed initially the maximum endurable energy of impact of the enamel. It consists of a steel tube (Fig. 1) through which a weight of a quarter, a half, three-quarters or one kilogramme falls on a steel sphere, driving it in the enamel surface. In setting up the instrument on the enamel surface the sphere is displaced, and then lightly pressed to the surface by a small spring; the weight then falls on this sphere. The plate is laid upon a slightly domed steel block and pressed down by the hardness tester until no play is possible.

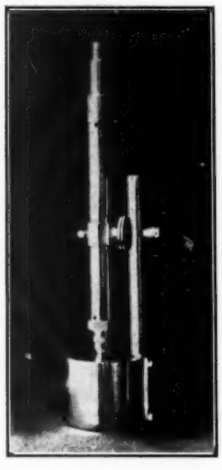


FIG. 1.—HARDNESS TESTER.

Even superficially there is a distinct difference between the various enamels when they are struck with the same force. The most resistant show a circular impression. The diameter gives, then, a measure of the resistance of the enamel to a sudden blow. With somewhat less resistant enamels, fractures occur sideways from the point of impact. The results of measurements of the diameter of a large number of blows show a considerably greater scattering. The third class of enamels showed, besides deep-seated destruction of the enamel and deep lateral fractures, numerous halos and cracks around the site, or radiating therefrom into the rest of the field.

The results of the impact resistance measurements with two different strengths at blow are collected in tabular form in the Paper.

It may be considered as definitely established that stannic oxide, as a mill addition, improves the impact resistance of all enamels. This improvement obviously differs greatly in individual cases.

It is more difficult to answer the question whether this improvement increases progressively within the amounts usually added technically, or whether at a definite level (for example, about 6 per cent.) it reaches a maximum and then declines. Table II of the Paper answers the question statistically, and leads to the conclusion that with a great number of enamels the increase of impact resistance is maintained with increased additions of stannic oxide.

Influence of the Opacifier on the Resistance of Enamels to Acids and Alkalis

The earlier, almost simultaneous, works gave the surprising result that the acid solubility of an enamel is not only determined by the solubility of the enamel-frit itself, but also by the opacifier added to the mill. According to personal investigations, there can be no doubt that, of all solid opacifiers, tin oxide acts most favourably on the acid extractability of the enamels. These experiments, however, were carried out with two enamels only, and the following questions remained unanswered:—

(1) Whether the favourable influence of stannic oxide on acid extractability is a general fact, valid for all enamels, or what action stannic oxide has in individual cases.

(2) Whether the effect is exhausted with the first acid extraction, or maintained on repeated extractions.

(3) Whether the effect concerns only the extractability of the enamel by acids, but appears also in extraction by alkalis.

(4) How the effect is manifested on alternate extraction with acids and bases.

These four questions were made the basis of an exhaustive investigation on numerous enamels of the above series and the results are detailed in the Paper.

In contrast to the author's former work, hemispherical dishes were used for the extraction experiments.

As extraction liquids there were used 10 per cent. acetic acid; 5 per cent. lactic acid and 10 per cent. soda solutions. The extraction was carried out for one hour at the boiling point.

The extraction values obtained in this way are given in two tables and shown graphically in Figs. 2, 3 and 4. From the data so obtained, the following conclusions as to the action of stannic oxide in the different enamel types may be reached:—

(1) The mechanism of extraction in the enamels of different series must be the same, both with acetic acid and lactic acid.

(2) The course of the extraction curves is repeated on a second extraction with the same acid almost exactly as on the first extraction.

(3) The increase of acid resistance of enamel, due to stannic oxide as a mill addition, is quite general. Only certain enamels with an abnormally high content of fluorides, which very rarely occur in practice, form exceptions.

* Paper presented at the annual conference of The Institute of Vitreous Enamellers in Birmingham.

(4) It is fairly general that the decrease in extractability is greater, the greater the absolute solubility of the enamel itself. The enamels with a high fluorine-content are again a notable exception.

(5) In contrast with the well-defined protective action which stannic oxide exerts towards the attack of acid liquids on the enamel, no such action is shown towards 10 per cent. soda solution. The extraction values for the first soda leaching are in all cases practically the same for stannic oxide-free enamels and those containing stannic oxide. In the following acid extraction, the stannic oxide shows its protective action, forcing the curves for the total extraction apart. The same phenomena can be noticed in the following extraction with soda and acid.

In the individual enamel series, the following special points may be mentioned:—

(6) It is not simple to interpret chemically the phenomena outlined in the various enamel series. The chemical characteristic of stannic oxide is its amphoteric nature. It is thus conceivable that the alkalis, for example, which may well be primarily responsible for a high total solubility of an enamel, are bound, with the formation of complex stannates and probably also silico-stannates. Stannic oxide would act as an acid in such a case, and would intensify the general action of silica in lowering the solubility of the enamel.

(7) The processes which take place in enamels containing fluorides must be of quite a different character. In the melts rich in fluoride, an interaction between sodium fluoride and stannic oxide with formation of complex tin fluorides would probably occur. The increased extractability may be due to the setting free of alkali through complex formation.

This reaction involves a simple exchange of oxygen from the loose binding in tin oxide to the strong binding in alkali oxide.

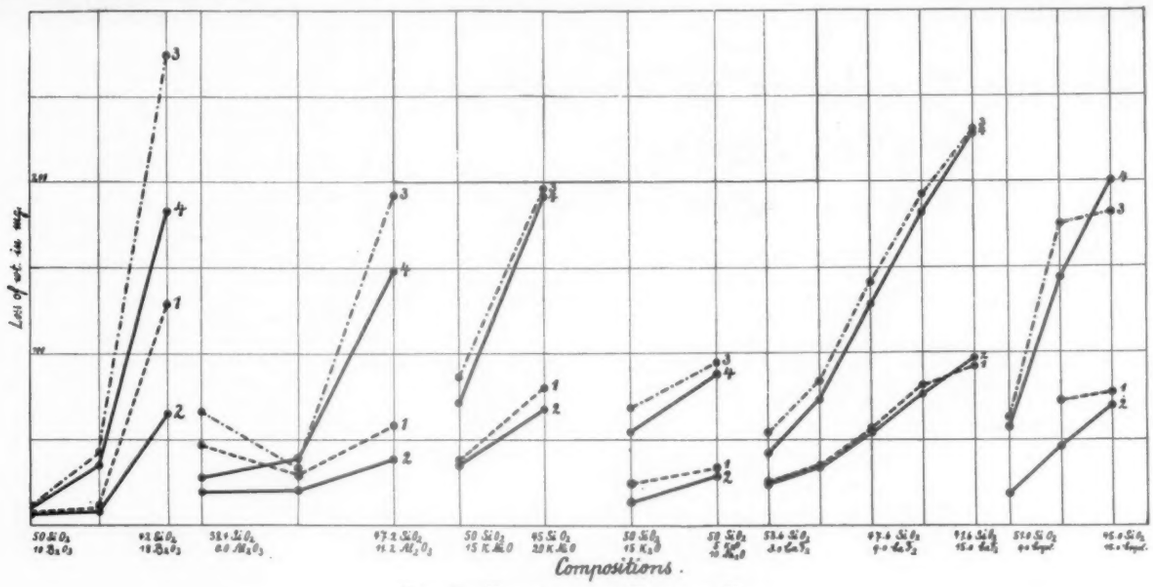


FIG. 2.—EXTRACTION OF ENAMELS (I).

(1) Enamel without stannic oxide in 10 per cent. acetic acid; (2) enamel with stannic oxide in 10 per cent. acetic acid; (3) enamel without stannic oxide in 5 per cent. lactic acid; (4) enamel with stannic oxide in 5 per cent. lactic acid.

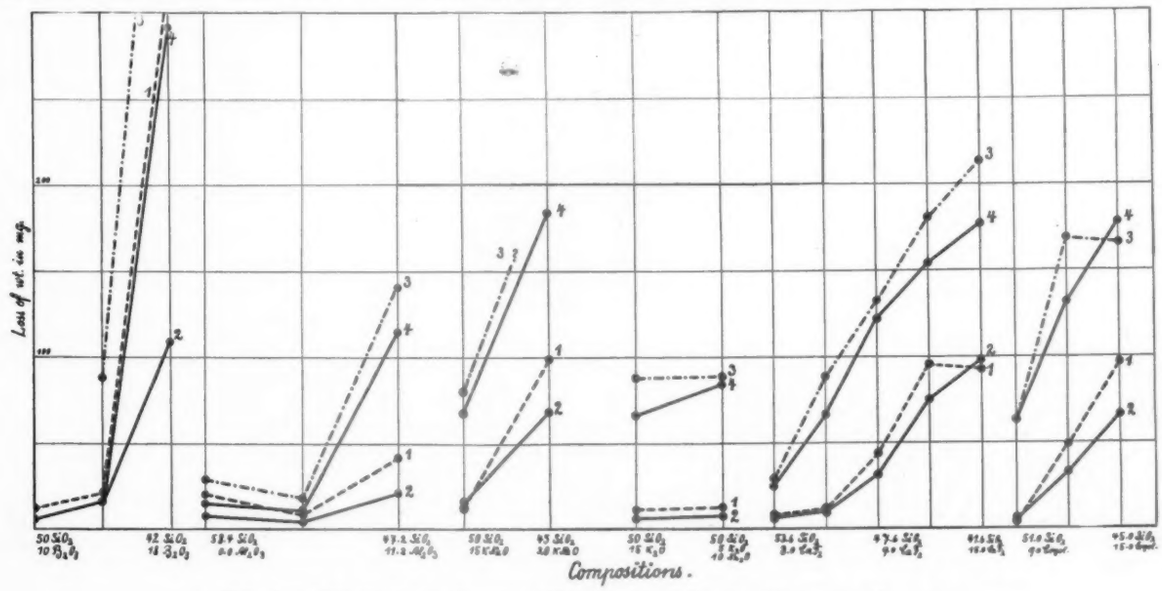


FIG. 3.—EXTRACTION OF ENAMELS (II). (1), (2), (3) AND (4) AS FOR FIG. 2.

Influence of Stannic Oxide on the Optical Properties of Enamels

The physical factors affecting the opacity of enamel are now well understood, and the problem might be considered as closed, since the optical constants of all opacifiers are known, and their particle sizes are relatively easily accessible to measurement. The opacity cannot be considered, however, from the viewpoint of the opacifier alone. In spite of the fact that stannic oxide is the most universal opacifying agent, the other partner in the phenomenon, the enamel, must also receive consideration.

The present work shows that a deeper insight into the phenomenon of opacification is gained by regarding the effect as a dynamic process. In preliminary work on these lines, Tetrick* observed that the opacification of enamel does not set in instantly, but requires a certain time for its development. A further step taken by the author is in establishing the fact that the development of opacity in many enamels is not complete even when the enamel is taken from the furnace as apparently fully fired. Further consideration required the investigation of the opacifying process in series of enamels of varied compositions, thus enabling the laws governing

* J. D. Tetrick, Journal of the American Ceramic Society, 1935, 18, p. 314.

opacification to be examined. Those considerations and investigations are not merely of theoretical interest, but have as their direct goal the maximum possible increase of opacification in practice, by combining the most suitable opacifier and melt with the optimal time of firing.

From the figures obtained by the measurements of opacity and gloss, the general conclusion may be reached that the increase of opacity obtained with longer firing goes with a decrease in lustre. This introduces a further complication into the process of technical enamel production, since lustre has to be considered as well as opacity. It must be borne in mind, therefore, that by endeavouring to exact from the enamel the maximum opacity, there is the danger of forfeiting 8 to 10 per cent. of the lustre, and this loss of lustre limits the attempts to reach the greatest possible opacity of the enamel. Fig. 5 shows in its left field the values for the opacity and lustre of enamels of the boric acid series, in the normal-fired (continuous line) and overfired state (dotted line).

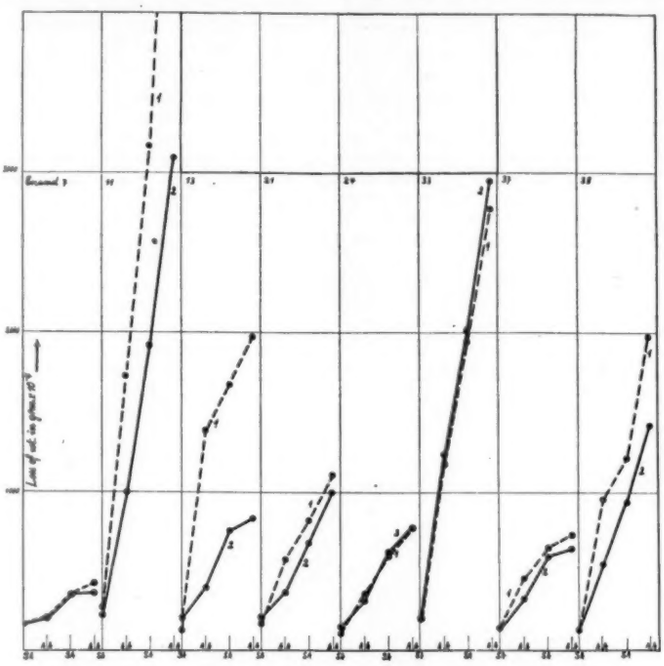


Fig. 4.—Alternating Extraction of Enamels with Soda Solution (SA) and Acetic Acid (AA).

(1) Enamel without stannic oxide; (2) enamel with stannic oxide.

From the figure the following may be deduced:—

(1) The specific opacity of the enamel-frits is independent of the ratio $SiO_2 : B_2O_3$. The values vary symmetrically about the mean line (drawn thin).

(2) The mean values for the opacity of the enamel with 6 to 10 per cent. of stannic oxide lie at first *above*, but after about 13 per cent. B_2O_3 *below* the total mean value; it is therefore in no case advisable to go beyond a boric oxide content of 13 per cent. in wet enamel-frits for stannic oxide.

(3) The deviation of the curves for the opacity in the normal-fired and overfired states with increasing fusibility of the enamel is noteworthy. The deviation of the curves implies that with increasing fusibility there is greater risk of being deceived by the enamel surface, rapidly melting out to a gloss; the surface lustre loses its value as a criterion. Even when it appears that firing is completed, the goods must remain in the furnace some time for the maximum opacity to develop. This is particularly important in practice when working with low additions of stannic oxide to the enamel, when the curves show a greater tendency to divergence. The correct firing of the enamel by timing is especially important in such cases to take full advantage of the specific opacity of the enamel.

Fig. 6 shows the measured values for opacity and lustre of the enamels of the aluminium oxide series in the normal-fired and overfired states. The curves for the opacity of the enamels with 6 per cent. of stannic oxide are *f* and *g*. From these curves, conclusions may be reached which are valid not only for the special case of opacification with stannic oxide, but for the whole field of enamelling. They are therefore dealt with in some detail here.

The specific opacity of the enamel falls continuously both in the normal-fired and overfired states; this fall may have three causes, which are discussed in the Paper.

The third cause, the deposition of crystals from the supersaturated melt, is determined, according to Tammann, by two governing factors, which are independent of one another and exist simultaneously: (1) the *nuclear number*, *i.e.*, the number of crystallisation centres formed in unit volume, and (2) the rate of crystal growth, *i.e.*, the increase in size per second of the separated crystal nuclei. Both magnitudes increase to a definite maximum with supercooling of the melt, and then, as is peculiar to the vitreous state, practically disappear. The maxi-

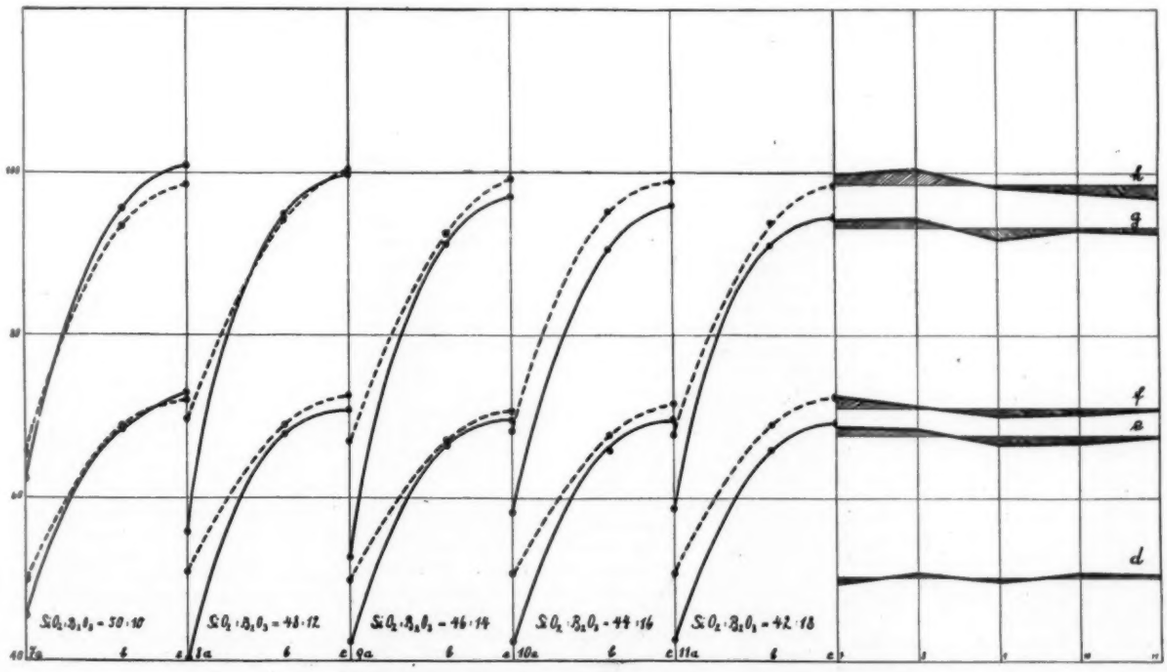


Fig. 5.—Opacity and Lustre of Enamels with Variation of the Silica-Boric Acid Ratio.

mum devitrification and the highest value of pre-opacification will occur with an enamel when the firing temperature is, simultaneously, the temperature of maximum nuclear number and strongest crystal growth. The nuclear number depends on the degree of supercooling of the enamel, which is probably the same for all. It may therefore be assumed that the number of crystallisation nuclei is nearly the same for all enamels. Thus, the difference in the rate of development of opacity is associated to a great extent with the rate of growth of the nuclei, and this forms the key to the understanding of the phenomenon. The rate of growth of the crystal nuclei is a question of diffusion velocity, which depends on the viscosity of the enamel. Accordingly, the retardation in rate of development of opacity is naturally the greater, the more the viscosity of the enamel melt rises with increase in aluminium oxide content.

Proceeding now to the individual enamels, the slips containing stannic oxide show that the overfiring curves for the three first enamels are mostly below the normal curves. The addition of stannic oxide has thus caused rapid devitrification, with deposition of the pre-opacifier, but this opacity is partly lost in the further course of overfiring, probably by evaporation or by uniting to large crystal aggregates.

In using enamel melts with a very small content of aluminium oxide (below 8·4 per cent.), the rapid and complete development of opacity, on firing to lustre, can be ensured by the use of stannic oxide. The absolute value of the opacity is also very high, and exceeds that of enamels richer in aluminium oxide. This opacity is not very stable to firing, however, and on strong firing declines considerably, to the degree reached with Enamel 16 (richer in aluminium oxide) on normal firing. The loss of lustre must also be considered with melts so poor in alumina. The most valuable enamels contain upwards of 8.5 per cent. of aluminium oxide. Opacity and lustre are practically independent of the time of firing for enamels with about 9 to 10 per cent. of aluminium oxide. By increasing the aluminium oxide content of the melt still further, it becomes more and more difficult to develop the opacity completely within an economically practicable time of firing.

Passing over the enamels with variation of alkali-soda-potassium oxide, it is only necessary to point out that at the proportion of SiO_2: KNaO=50:15 and 6 per cent. stannic oxide, opacity and lustre are developed in the normal firing time and within this proportion of silica: alkali oxide 50:15, the proportion of $K_2O:Na_2O$ is without any significance.

Enamels of the Silicic Acid-Fluorspar Series

On firing the melts mixed with 6 per cent. of stannic oxide, a mobilisation of the pre-opacification of the enamel takes place near the beginning, corresponding to curve *g* (Fig. 7). The best enamel for the use of stannic oxide as opacifier would be one for which the opacification curves in the normal and overfired states lay as close together as possible. This is the case for enamels containing 6 to 9 per cent. of fluorspar. Practical experience also confirms that such enamels are particularly suited for opacification with stannic oxide. The opacity of the enamels with 6 to 9 per cent. fluorspar is developed on firing to full lustre, and is also very stable towards overfiring. It is possible to effect still greater opacification with higher fluorspar content, but the stability towards firing is less. The same considerations hold even in greater degree for lustre.

The Silicic Acid-Cryolite Series

From the practical viewpoint, consideration of the curves in the cryolite series shows that the possibility of variation in the composition of enamels containing cryolite is limited. In the whole series of five enamels, only one is completely satisfactory with regard to the magnitude, stability towards firing, and rate of development of opacity. Enamels with less cryolite develop the opacity too slowly, even when so sovereign an opacifier as stannic oxide is responsible and accelerates the process as a catalyst. Melts with more than 12 per cent. of cryolite give a very high opacity with 6 per cent. of stannic oxide, but this is reduced considerably on overfiring, a change which not even stannic oxide can prevent.

In technical literature dealing with enamels, the opinion is justifiably put forward that the opacifying action of stannic oxide is intensified by that of the fluorides. This view is confirmed by these experiments, at least above certain concentrations of fluorides. It was not known, however, that stannic oxide itself creates this additional fluoride opacity to a great extent. By its presence the latent opacity of the melt is first mobilised in many cases; without the catalyst stannic oxide, this would occur only slowly or to a small degree.

The factors which considerably influence the opacification of the enamel by stannic oxide are aluminium oxide, fluorspar and cryolite, and by suitable choice of these components a particularly favourable enamel for opacification can be obtained. Experiments on the formation of such an enamel, particularly suited for stannic oxide, will be described in the next part of the work.

As is well known, it is not possible to make a universal enamel which possesses simultaneously the optimum values in all its properties. It would therefore not be correct to seek out only one or a few enamels and postulate these as being most suitable for opacification with stannic oxide. It is much more correct to define a certain field, embracing enamels which, for example, represent the optimum as regards opacification with stannic oxide, have very good firing stability, and leave sufficient play for finding the optima as regards other properties. As the most important property, the opacification is naturally taken, since this is the main purpose of the stannic oxide. Not only the magnitude, but also the firing stability of the opacification is an elementary requirement which the enamel must fulfil, if it is to be used technically.

The preceding experiments have shown that silicic acid, boric acid and the alkalis have little influence on either the magnitude of the opacification or the rapidity of its development, within the limits that are imposed by the other technical requirements of the enamel. They can therefore remain constant during all the alterations undertaken in the enamel mix. The degree of opacity is influenced very strongly by cryolite and fluorspar, while aluminium oxide has a great influence on the kinetics of opacification. These three enamel components had to be varied, therefore, in the first place. Previous experiments have also shown that a constant of 9 per cent. of these components has in each case proved most favourable.

The insight obtained into the kinetics of the opacification process indicates for the determination of opacity and lustre another procedure, which has the advantage of approximating more loosely to the actual conditions of large-scale working. This other type of firing should, also, bring confirmation of the conclusions already reached with intermittent firing. As with every kinetic investigation of a process, the test samples were maintained at a constant reaction temperature for different times and the opacification and relative lustre produced after different times were measured. The values are recorded graphically in Fig. 8. The dotted line applies in each case to the opacification and

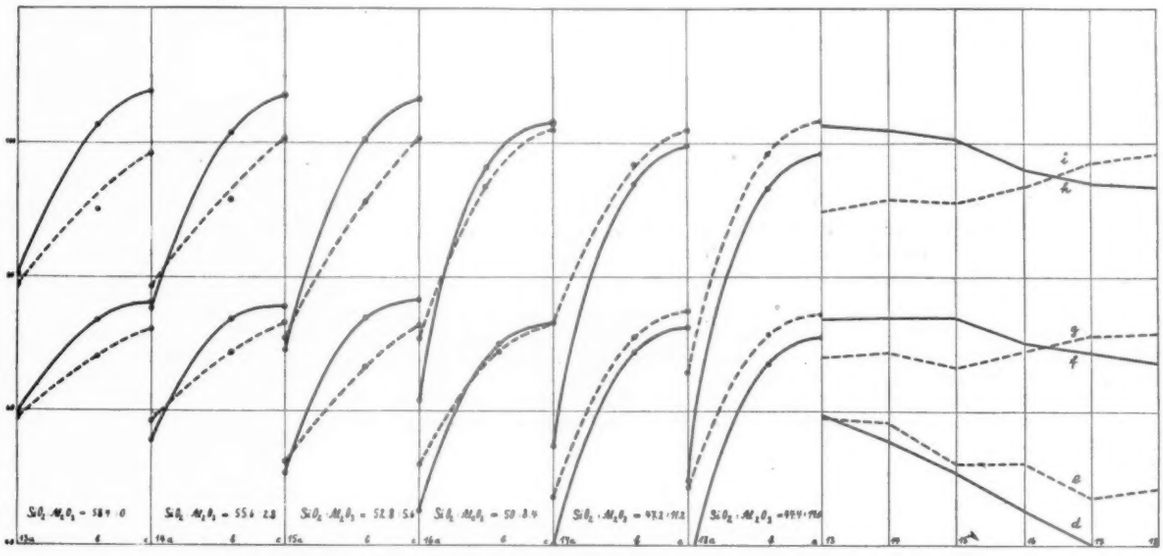


Fig. 6.—Opacity and Lustre of Enamels with Variation of the Silica-Alumina Ratio.

lustre of the enamel with a mill addition of 6 per cent. of stannic oxide, the continuous line for an addition of 3 per cent. From the curves, some important deductions may be made as to the magnitude of the opacification, its rate of development, and the firing stability of the enamels in relation to the varied enamel components.

(1) A smaller cryolite content particularly favours the phenomenon of hysteresis in the opacification.

sponding fluorspar values are 7.4 and 5.5 per cent., *i.e.*, a mean of 6.3 per cent., and with an aluminium oxide content of 9.1 per cent. These figures are in complete agreement with the regularities found in the variant enamel series which were derived on the basis of a *different* firing process.

(3) It is noteworthy that all the opacification and lustre curves for the enamels with 6 per cent. of stannic oxide are much smoother than those for the enamels with 3 per cent. constant, and which do not burn out even on long firing. Thus, stannic oxide appears in a new and not less important rôle— as a stabiliser for the costly pre-opacification of the enamels by the fluorides, especially cryolite. The stannic oxide appears to play this rôle, however, only with mill additions above 3 per cent. Even in Enamels 45 and 46, which rapidly decline in lustre and opacification, the stabilising action of the higher content of stannic oxide is observed. The slope of the

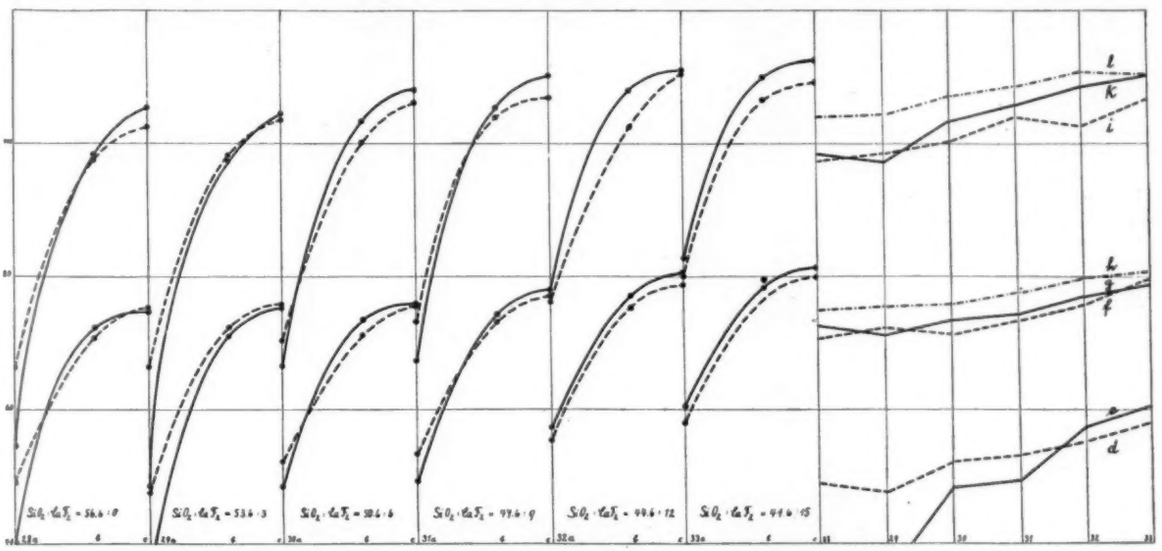


Fig. 7.—Opacity and Lustre of Enamels with Variation of the Silica-Fluorspar Ratio.

(2) From Enamel 43 onwards, where the cryolite content finally rises above 11 per cent., the delay phenomena cease. Opacification may remain constant or may decrease, at first slowly, and then rapidly. In Enamel 45, poor in cryolite but rich in fluorspar, after the full development of the lustre a slow, and in the

They show no abrupt peaks. This confirms the catalytic action of the stannic oxide which activates the opacification, especially by cryolite, and accelerates its appearance.

(4) A further effect of stannic oxide additions over 3 per cent. is the much greater firing stability which the higher concentration

curves is appreciably less than that of the corresponding curve for enamel with 3 per cent. tin oxide. The stannic oxide, it is true, can no longer prevent the decline in opacification, but it has decisive influence on the rapidity of the decline, so that it occurs with considerably less speed even with the enamels

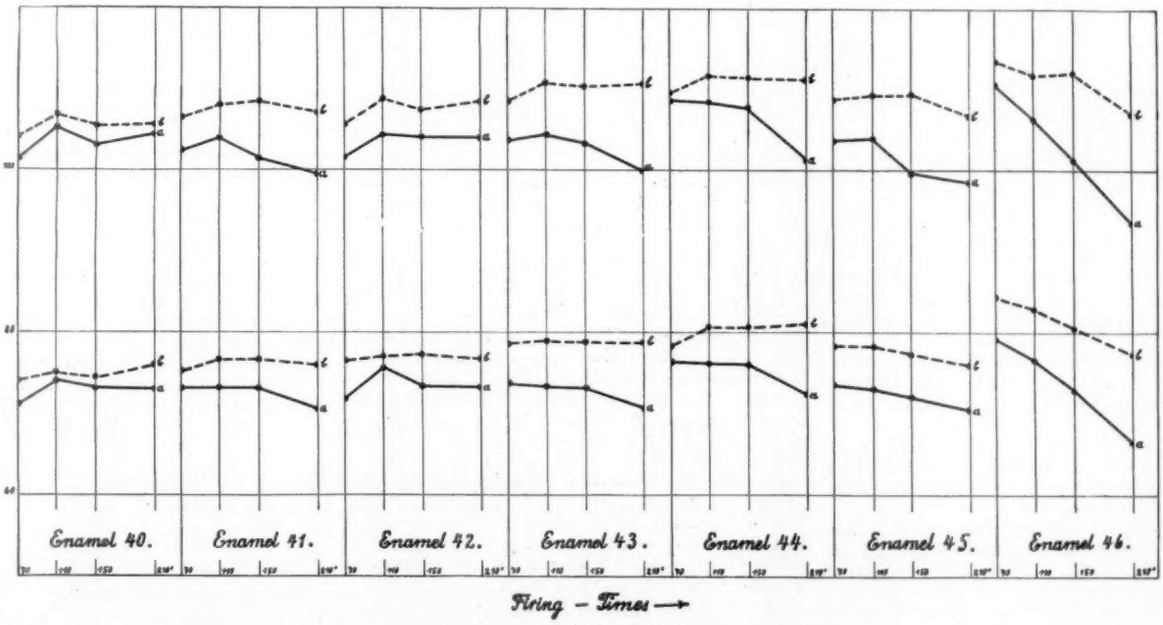


Fig. 8.—Rate of Development of Opacity and Lustre.

cryolite-rich Enamel 46 a rapid, and continuous decline in opacification and lustre takes place as the time of firing proceeds. The most favourable cryolite content lies, therefore, in Enamels 43 and 44, *i.e.*, between 11 and 12.9 per cent., or about 12 per cent. The corre-

of stannic oxide confers. Thus, for example, the opacification curve in Enamels 43*b* and 44*b*, as also the lustre curve for the enamels with 6 per cent. of stannic oxide, runs practically parallel to the abscissa, giving enamels in which both opacification and lustre remain

rich in cryolite. The relatively high firing stability of technical enamels with more than 12 per cent. of cryolite can be traced, in part at least, to this cause.

(5) The enamels most suited for opacification with stannic oxide lie therefore within the field

marked with the letters *a* to *f* in the aluminium oxide-fluorspar-cryolite triangular diagram.

(6) The enamels most suitable for opacification with stannic oxide group themselves almost symmetrically around Enamel 43. The tie line 41-43-45 divides the field into the subdivisions of melts with slowly produced, but very stable opacity, and those with opacity developing simultaneously with optimum lustre, but less stable to firing. The enamels to the left of this line must accordingly be fired somewhat longer when the surface lustre has already fully developed; enamels to the right of the line must be taken from the furnace immediately the surface has fired to a gloss.

(7) The extension of the field of enamels optimal for opacification with stannic oxide, enables the melt to be chosen from other viewpoints than lustre and opacification.

In conclusion the author thanks the International Tin Research and Development Council in London, and the Verein Deutscher Emailfachleute, for the assistance rendered to him in the prosecution of the present researches. He also expresses his deep appreciation of the very kind reception accorded to him during his stay in Birmingham.

DISCUSSION

MR. D. J. MACNAUGHTAN (International Tin Research and Development Council) recalled that some years ago he had discussed with Dr. Mellor, the first President of the Institute, the desirability of research on the use of tin oxide as an opacifier; Dr. Mellor had been very emphatic as to the desirability of such work, and there was discussion as to the various ways in which the work might be carried out. Subsequently Mr. Macnaughtan had made inquiries as to who should be asked to undertake the work, which must be done in a thorough and systematic manner, and quite a number of leading manufacturers of materials had suggested approaching Dr. Stuckert. Accordingly, Mr. Macnaughtan had travelled to Munich to discuss the matter with Dr. Stuckert, and subsequently had made further visits to his laboratories from time to time. There was no need to emphasise the enormous amount of work that Dr. Stuckert had put in. Although that work had been done abroad, it was a matter for gratification that it had been presented in this country, and its presentation had been made possible only by the existence of the Institute. At the time the work was mooted, the Institute was in its very early stages of development; it had since developed to a stage at which it could assemble together a number of people interested for the purpose of considering questions of a fundamental character concerning the industry. Undoubtedly its future success would be determined largely by the degree to which it continued that policy.

MR. W. E. BENTON asked whether Dr. Stuckert was considering the publication in the English language of his valuable book "Die Emailfabrikation."

DR. STUCKERT replied that it had been translated and published in sections in "The Ceramic Age," of America; it was not published there in book form, however.

The PRESIDENT (Sir Harold Hartley) said that, as a physical chemist, he admired greatly the fundamental manner in which the investigation described in the Paper had been carried out.

In asking for Dr. Stuckert's views concerning the application of petrographic, X-ray and electron diffraction methods to the study of enamels, he said the Paper had given the results of physico-chemical investigations indicating certain relationships between lustre and opacity, on the one hand, and composition and time of firing, on the other. Those results, and the references which had been made by one or two speakers to the lack of really basic information as to the condition of enamels, led the President to recall that he had learned petrographic methods from Dr. Weinschenk, at the Technische Hochschule, Munich, some 40 years ago, and that the use of the petrographic microscope had enabled him to avoid blunders in chemical problems. The simplest method of examining enamels for the purpose of securing further fundamental information was to use the petrographic microscope; but nowadays we had also the more powerful methods of X-ray analysis and electron diffraction. It seemed to him that the more fundamental attack on the constitution of enamels depended very much on the possibilities of the application of those three methods. Therefore, he asked whether Dr. Stuckert intended to continue investigations along those lines in order to ascertain the factors which determined the relationships indicated in the Paper, which had so great a bearing upon the problems of the industry.

DR. STUCKERT (whose reply was translated by the President) said that investigations on petrographic lines had already commenced; but he pointed out that it was a difficult matter, for it was necessary to prepare transparent sections, to cut sections of the enamel, in order to apply petrographic methods. However, he hoped that petrographic investigations would yield further explanations, and particularly that they would show what was the condition of the tin oxide or the antimony oxide in the enamels. He agreed that that was the only way in which one could secure a full explanation of his physico-chemical curves, and he believed that petrographic investigation was likely to yield quicker results than X-ray analysis. Investigations on these lines had already been carried out, but they had not given very well-defined differences.

FIG. A.

MR. G. H. ABBOTT (London) said that the Paper gave some very careful analyses showing the effect of composition, in respect to stannic oxide, on opacity, and he asked whether Dr. Stuckert had information relating to other opacifiers.

DR. STUCKERT replied that he had not yet had time to do the work which would yield such information.

The CHAIRMAN (Mr. Whittle) asked whether Dr. Stuckert had carried out tests concerning the coefficient of expansion of the oxide of tin as against that of substitutes.

DR. STUCKERT replied that he had not yet had time to carry out such investigations, but he believed the influence would be small.

The CHAIRMAN added that he had mentioned the point because the early enamellers, when building up an enamel, tried to use materials having one or more functions. One of the main reasons why cobalt was used in the ground coat was that it had the nearest coefficient of expansion to that of iron. Oxide of tin was the next most suitable commercial material, having the nearest coefficient of expansion to that of cobalt. Therefore, he had wondered whether Dr. Stuckert had found any great advantage in using oxide of tin as an opacifier as against ordinary substitutes from that point of view.

DR. STUCKERT said that the effect of cobalt oxide had no relation to its expansion coefficient; that the expansion of the ground coat approximated to that of the iron was due to the fact that the ground coat dissolved up to 20 per cent. Fe_3O_4 (formed by oxidation of the iron) and thus had its expansion coefficient raised from approximately 280 10^{-7} to 380 10^{-7} (Fe approximately 400 10^{-7}). According to King, and particularly to Dietzel, the cobalt oxide has an electro-chemical action. An element Fe/FeO—CoO/Co is formed with current flowing from left to right and a p.d. of approximately 0.23 volt. Fe enters solution and Co is made up from the enamel, which changes its colour from blue to black. The Co is precipitated on the iron which shorts the cell and also now causes a rapid solution of the Fe and a pronounced "corrosion" of the Fe surface with the formation of Fe dendrites, as shown in Fig. A. The enamel adheres to the surface which has been chemically roughened in this way. The only adherent oxides are therefore the oxides of metals which are slightly more electropositive than iron, the best being CoO and NiO, and those precipitated by Fe from the corresponding glazes. He intended to undertake investigations on the expansion coefficients of the tin-oxide enamels, but so far had not had time to do it. He had used tin oxide initially as being the classical example of an opacifier; but there were many variants, of course, and gradually the work would be extended.

It was intimated that Dr. Stuckert was anxious to receive questions with regard to the work, and that he would be glad to reply to any written questions submitted to him in the future. Members were asked to submit such questions to the Secretary of the Institute, who would forward them to Dr. Stuckert.

Votes of Thanks

The PRESIDENT (Sir Harold Hartley) moved a hearty vote of thanks to Mr. Benton and Dr. Stuckert for the Papers presented to the meeting, and expressed gratitude to Dr. Stuckert for having travelled from Munich for the purpose of presenting his Paper. The Paper had been prepared in a manner in which it was extremely easy to read and understand, but it was a great advantage to meet Dr. Stuckert also.

The President also proposed a vote of thanks to Mr. J. W. Gardom, Mr. Walter S. Grainger and Mr. W. Todd, who had been largely responsible for the organisation of the meeting. The arrangements, he said, had been perfect, and he was sure everybody would agree the meeting had been a great success.

The votes of thanks were carried with acclamation.

MR. S. HALLSWORTH proposed a vote of thanks to Sir Harold Hartley for his services as President during the course of the meeting. The members, he said, were delighted to welcome Sir Harold, whose immense prestige would be of infinite value to the Institute. His address had been a real inspiration, and well interpreted the Institute's major aspirations. Everybody hoped he would remain their President for many years to come.

MR. A. ENGLAND seconded, and also paid a tribute to Sir Harold.

The vote of thanks was carried with enthusiasm.

The PRESIDENT, in a brief response, assured the members that he was honoured to have been asked to serve as President, and that he would be delighted to do anything he could do to help the Institute. He would carry away, he added, the most pleasant recollections of the meeting, from which he had gained a little insight into the problems of the industry.

Foundry Production in the U.S.S.R. and U.S.A.

MR. L. Y. BERRY, in "Liteinoe Delo," No. 4, 1937, gives a review of the available statistics, which show that the increased output of foundry products in the U.S.A. following upon the trade recovery is not so rapid as that of engineering products in general, one reason being the considerable demand for products in which the necessity for castings is relatively small. The Soviet foundry industry, on the contrary, is progressing at an ever increasing rate. Mechanisation plays a considerable part in the U.S. foundry industry, although the degree of mechanisation varies from foundry to foundry.

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The Evolution of Enamelling

DISCUSSION ON Mr. W. E. BENTON'S PAPER

When MR. W. E. BENTON presented his Paper on "The Evolution of Enamelling,"* at the fourth annual conference of The Institute of Vitreous Enamellers last month, he gave a number of illustrations by means of lantern slides of some early, as well as modern, decorative enamels. Some actual pieces were also exhibited showing that modern enamel can still be used for decoration. An outstanding one was a casting of Leonardo da Vinci's Last Supper, kindly lent by Mr. C. P. Stone.

Standardisation Needed

The discussion was opened by MR. A. ENGLAND, who recalled that about twelve months ago Mr. Benton had asked him to look over some notes he had made concerning some old Bilston enamels. Those notes had proved of great interest, and therefore Mr. England had suggested to Mr. Grainger that he should ask Mr. Benton to lecture to the Institute. The Paper had resulted from that, and its presentation had been most pleasurable, interesting and instructive. He had had no idea that Mr. Benton would have made so deep a research concerning the old enamels as he had done.

The Institute of Vitreous Enamellers, continued Mr. England, had not yet put forward a standard of enamels or an approach to a standard. Various people, however, had put forward certain standards, and had stated the tests which it was considered good enamels should withstand, but any chemist would conclude that some of those tests were impossible. For instance, one worker had stated that all enamels should withstand scratching to a Mohr's scale of hardness at 7. There were certain others which Mr. England had considered ridiculous, to say the least, and he urged the Council of the Institute, therefore, to endeavour to enunciate, with the help of everyone concerned, a standard to which enamellers should aim, for that would constitute a great forward step.

In regard to research, he felt that we were still only on the fringe of the subject; we were still working to a large extent with empirical methods. It was true that scientific calculations were applied to the results, but he was aware of no one who could tell him what an enamel was. He had seen it defined as a boro-silica-fluoride; but he did not believe it. He considered it was simply a mixture which had been evolved by empirical means, and we needed another Lavoisier to tell us what we were really doing. Of course, he added, it would not do for us to discover it all at once!

The CHAIRMAN (Mr. W. H. Whittle) assured the meeting that the Council was considering the appointment of a Standards Committee, on which technicians would be invited to serve, with a view to arriving at a standard.

Designing for Industry

DR. H. T. ANGUS congratulated Mr. Benton on having made a masterly survey, compressed to within a short space, of the history of enamelling from the earliest times, and commented particularly upon the remarkable manner in which the early enamellers had overcome their difficulties. They had had to work with materials of all degrees of purity, so that they could not have anticipated their results with accuracy. Obviously, they had known how to do their job and to describe their materials and methods.

The tendency to-day was to design iron to be enamelled; but Mr. Benton's suggestion was that the industry should endeavour to design enamelled iron, which was not quite so simple a matter. To a large extent the industry was engaged in the mass production of materials which were meant for general use, and it was a modern tendency to make utility serve for beauty and to regard anything extraneous, anything added deliberately for decorative purposes, as being probably non-æsthetic in the long run. A definite change had occurred during the last seven or eight years in the designs for cast iron and pressed steel enamelling; no longer did we see the decoration that was used formerly, and almost the whole industry was changing over to characteristic shapes and designs. The tendency towards greater beauty would come about naturally.

With regard to standardisation, he said that standards were all very well, but it was dangerous to stick to rigid standards in a comparatively new industry. The standards to which Mr. England had referred were very admirable as a means of securing some sort of order out of what was originally chaos. Dr. Angus did not consider the specification of the Mohr's scale of hardness at 7 as being absurd, so long as one had regard to the method of scratching that was applied. The time had arrived for further standards to be laid down, but they would have to be revised from time to time; so long as it was understood that they would be revised ultimately, and that they were not to be held too rigidly but must be regarded as a guide to further practice, no exception could be taken to the suggestion to apply them.

The CHAIRMAN said that Dr. Angus was correct when he had said that the tendency to-day was for the bulk production of the utility article to be sold at a certain price, and produced mostly by workmen as contrasted with craftsmen; under present-day conditions industry expected much in a short time. The examples of enamelled articles which Mr. Benton had exhibited were produced, however, by craftsmen, and the production of those articles had no doubt occupied quite a long time. That was the difference between the two types of articles.

MR. C. P. STONE, whose family had been associated with enamels and enamelling for more than 70 years, including experiments with the Bilston enamels, said that he had in his possession some of the old Bilston enamels and the formulæ for making them; on the enamelled plaques, one of which represented da Vinci's Last Supper, exhibited at the meeting, some of the formulæ were used in the production of some of the champ-levé effects. Incidentally, the plaque was enamelled direct to iron and had been through the furnace thirteen times and its production had occupied a period of 5½ days from start to finish. It had been exhibited in order to bring the ancient and the modern together, to show that with the aid of the artist a great deal can be accomplished. There was much to be said for the practice of the early antique enamellers who, it was important to note, had always worked on fine metals, silver and gold, which were of extreme purity. Silver and gold were still the best-known metals for artistic enamelling, and indeed it was necessary always to use fine quality metals for enamelling, whether those metals be iron, cast iron or C.R.C.A. steel. The main reason for the success achieved by the early enamellers in superimposing a heavy coating of porcelain on to very thin copper, silver or gold was that the mechanical strength of the metal they used was infinitely less than the strength of the enamelling materials applied to it. If a piece of enamelled iron or steel sheet were subjected to a moderate blow, the metal would bend or dent under the impact and the enamel would fracture. On the other hand, a piece of enamelled cast iron would withstand a very heavy blow, even though the enamel in itself had no greater strength than that which was applied to sheet; the reason for its ability to withstand a very heavy blow was the high mechanical strength of the casting against that of steel. He was afraid that if the old-time enamellers had had to work on metal having the same strength as that used to-day, probably in the nature of 16 or 18 gauge, they would have failed miserably. Mr. Stone was firmly of opinion that the enamel used on signs 30 years ago was considerably more resistant generally than the enamel prevailing to-day, for the reason that at that time the enamellers could obtain charcoal iron, which was very different from the metal available to-day. He could remember occasions, up to 1910, when the ground coat was applied in the month of January, the first coat of white was applied probably in February or March, and when the official order was confirmed, the products would be finished in white in June or July. In those days one never heard of fish scaling with charcoal iron. The iron, however, would not bend, but would break when bent with the grain, and he suggested that it would be worth while endeavouring to recapture the qualities of charcoal iron with the addition of the bending properties possessed by modern metals.

Mr. Stone was in entire agreement with Dr. Angus that the Mohr's hardness scale of 7 could be applied as a standard with advantage. It was a standard which had worked regularly up to three years ago. But the ability of enamelled ware to withstand that test must not be interpreted too widely; regard must be had to the manner in which the test was applied. However, the application of the test by a company of great repute had carried us a considerable distance towards standardising enamelled ware.

Emphasising the remarks made in the Presidential Address, following a reference to synthetic finishes, that we must not take it for granted that the porcelain enamels of to-day were sufficiently good to resist for all time the competition of new materials which might be introduced, Mr. Stone said he had urged on several occasions that enamellers should look to their laurels, that unless they produced finishes which were of the very best in respect of beauty, durability and resistance to staining, they would one day see the introduction of something different which would supersede enamel finishing. Quite a number of those in the enamelling industry had made tentative researches with a view to providing those fine finishes which would withstand modern conditions, but he did urge seriously that a definite standard should be set and that that standard should be a high one. Stain proof, resistance to heat and mechanical shock should be some of the ends sought.

The CHAIRMAN, commenting upon Mr. Stone's reference to the desirability of producing a metal having the properties of charcoal iron, plus the bending properties of modern iron, pointed out that the metal producers to-day are providing sheets in much better form and of a much better finish than were available formerly. The old charcoal iron was rough, and it had to be subjected to scaling treatment, which involved treating it with acid and placing it in a scale muffle in order to remove the dirt, etc. That scaling process, however, had a dual purpose, for it also effected the annealing of the metal, rendering it more suitable for the grip coat. The metal provided to-day was of much better finish than that provided formerly, but we were rather overlooking the annealing. Anyone using fabricated sheet metals to a great extent would be well advised to grease-burn or anneal them, for such treatment would remove strains and stresses from the metal and the enamel applied to it would have a much better grip than if the metal were not so annealed.

MR. STONE said it was important to remember that ground coats which were applied to the old charcoal iron did not require a metallic content of any kind—either cobalt, nickel or manganese. The standard formula used in those days was of very simple construction; the material had no metallic content whatsoever, and fish-scaling was then unknown.

* FOUNDRY TRADE JOURNAL, October 14, pp. 307-310.

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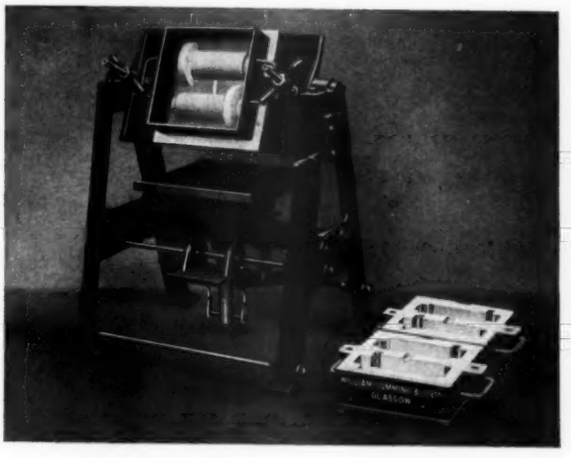

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The Week's News in Brief

Trade Talk

The maintenance department of Glenfield & Kennedy, Limited, Kilmarnock, held their annual smoking concert last week.

Forges, Fonderies et Laminoirs de Nimy, the Belgian iron and steel works, report a net profit of 3,600,000 fcs. for the year 1936-37, against 820,000 fcs. in 1935-36.

The roof of the sand-blasting department of the foundry of the Steel Company of Scotland, Limited, at Hallside Works, Newton, near Glasgow, was destroyed by fire last week.

Imperial Chemical Industries, Limited, has been commissioned by the Government to erect a factory on its Landore site at Swansea, for the manufacture of munitions. It is anticipated that building will start shortly

The establishment of technical classes for the furtherance of the study of metallurgy was discussed at the annual meeting of the Ebbw Vale Metallurgical Society. Sir William Firth was elected President, Viscount Greenwood patron, and Mr. Arthur Woodward chairman, with Mr. J. C. Williams secretary.

The Belgian Phénix Works report a net profit of 35,100,000 fcs. for the year to June 30 last, against 13,510,000 fcs. in the previous year. A net dividend of 75.80 fcs. per share is recommended, against 37.90 fcs. in 1935-36. During the year the concern increased its capital from 53,500,000 fcs. to 80,000,000 fcs. by transferring a corresponding sum from the reserves.

Mr. L. Iversen, of the Mesta Machine Company of America, is at present on a visit to this country in connection with the new 60-in. continuous strip mill for the Hawarden Bridge Steelworks of John Summers & Sons, Limited, Chester. The mill, it is understood, will have an output of about 600,000 tons per annum, and will be completed some time during the latter half of next year.

Intimation has been received by the Executive Committee of the Ayrshire Development Council that the British Aluminium Company, Limited, have decided that conditions in Ayrshire are not such as would justify their new works being erected in the county. The British Aluminium directors have decided in favour of a site at Newport, Mon.

A company which proposes to build a rolling mill in Norway has been registered at Oslo. The mill is to manufacture products hitherto not produced in Norway. The annual output of the planned works is estimated at 80,000 tons, although the initial capacity will be limited to half this tonnage. The cost of the plant is put at 6,000,000 to 8,000,000 Kr.

The old-established business of the Haslam Foundry & Engineering Company, Limited, of City Road, Derby, is to be transferred to Glasgow. L. Sterne & Company, Limited, who have had control of the Derby foundry for the past three years, have decided to centralise the business at the Crown Ironworks, Glasgow. The Haslam works were founded in 1863 by the late Sir Alfred Seale Haslam, who was a pioneer in the manufacture of refrigerating plant.

Company Reports

Tweedales & Smalley (1920), Limited.—Interim ordinary dividend of 2½ per cent.

Anti-Attrition Metal Company, Limited.—Profit from October 2, 1936 (date of incorporation), to July 31, 1937, £22,451, after deduction of prior-incorporation profit of £671; interim dividend of 7½ per cent. was paid on 800,000 ordinary shares and final of 12½ per cent. on 1,000,000 shares is now proposed.

Lancashire Steel Corporation, Limited. — The directors announce that they have had under consideration the trading results for the period from January 1, 1937, which, they state, show an improvement on those for the similar period of last year. In view of the position, they have declared interim dividends on the 5½ per cent. non-cumulative redeemable second preference shares of 2¾ per cent., and on the ordinary shares of 2½ per cent.

Personal

Sir Herbert Walker and Mr. Charles F. Whigham have joined the board of the United Steel Companies, Limited.

Mr. C. C. Booth, J.P. (Vice-President of the London Branch of the Institute of British Foundrymen), and Mrs. Booth, were the recipients of a silver clock presented by the employees of Booth & Brookes, Limited, Mildmay Ironworks, Burnham-on-Crouch, in commemoration of their silver wedding last Friday. The presentation was made by Mr. G. Whiting, one of the employees with the longest service. Of the 140 of the present staff, no less than 36 were colleagues of Mr. Booth at the time of his marriage.

Obituary

Mr. Charles Edward Jones, of Ecclesall, Sheffield, died suddenly on October 20, on his 81st birthday. Early in his career Mr. Jones joined the staff of Charles Cammell & Company, Limited, and he remained with the company through its various changes. It eventually became Cammell, Laird & Company, and when this concern was merged into the English Steel Corporation, Limited, so far as its steel interests were concerned, Mr. Jones remained on the staff until his retirement six or seven years ago. Mr. Jones regularly attended the Manchester, Birmingham and Sheffield exchanges.

Sir Joseph Isherwood, Bt., the naval architect, died in London on October 24, in his 68th year. He began a distinguished career with Edward Withy & Company, shipbuilders, of Hartlepool, and later became a surveyor of Lloyd's Register of Shipping, leaving to develop his system of longitudinal framing for the construction of cargo vessels and oil tankers, and to set up on his own account as a naval architect. Numerous vessels were built on his longitudinal system, and later he produced an improvement on it in the bracketless system of construction for oil tankers. He was created a baronet in 1921.

Mr. George Thomas Wildsmith, chairman and managing director of Harrison & Company (Lincoln), Limited, malleable iron and steel founders, of Hykeham, Lincoln, died on Saturday, October 23, at Harrogate. He was 76 years of age. Mr. Wildsmith had been with Harrison & Company for over 45 years. For over 30 years he was managing director, and for nearly 20 years chairman, succeeding the late Mr. F. H. Harrison, founder of the firm. Born at Ashbourne, Derbyshire, he worked as a young man with Sir Francis Ley, of Derby, and after a period with the Nottingham Malleable Iron Company, he joined Harrison & Company.

New Companies

(From the Register compiled by Jordan & Sons, Limited, Company Registration Agents, 116 to 118, Chancery Lane, London, W.C.2.)

Windsor-Richards, Son & Company, Limited, Knockholt, Kent.—Capital, £100. Directors: Mrs. L. Windsor-Richards and E. J. Windsor-Richards.

James Sykes (Charcoals), Limited.—Capital, £1,000 in £1 shares. Manufacturers of and dealers in charcoal, moulders' powders, engineers' and ironfounders' supplies, etc. Director: O. L. Spedding, Park Hill, Millbrook, Stalybridge.

Contracts Open

Glastonbury, November 9.—Iron castings, for the Town Council. Mr. R. O. Winfield, borough surveyor, High Street, Glastonbury.

Dublin, December 20.—Supplying and laying of 6,000 yds. of 30-in. cast-iron main, for the Town Council. The City Treasurer, Exchange Buildings, Lord Edward Street. (Fee £5 5s., returnable.)

Correspondence

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

From Mr. G. H. Rutland, M.B.E., Head of Department of Engineering (Production), Wolverhampton and Staffordshire Technical College.

Apprentice Moulder Training

To the Editor of The Foundry Trade Journal.

Sir,—As one who is interested in the training of foundry trade workers, I have followed with interest the recent articles and correspondence on the subject. I was especially attracted by the Paper given by Mr. Bunting, and certainly agree with most of his remarks, although it appears to me that his syllabus, as set out, is more particularly directed to the welfare of the would-be executive than to that of the floor worker who aspires to foremanship.

In the syllabus for which I am to some extent responsible, we endeavour to enable the moulder to appreciate the difficulties of the pattern-maker and *vice versa*, and also to let both branches appreciate the point of view of the machinist by practical work in the foundry, patternshop and machine shop. With regard to the value of a foundry in a technical college, the need for this is outstanding. In a production foundry there is no time for inquests and little for individual instruction; in my day wasters were either made "saints" or "sailors"; in a college foundry there is time for inquests, and the causes of wasters can be tracked down by careful study of the methods employed in producing the casting. This is, in my opinion, the great value of such an "experimental" foundry; production is not the prime object, study of processes, methods and results should be the aim.

There is undoubtedly an advantage in practical work; no lad can learn his trade in a technical college, but he can study methods and, with a teacher who knows his job and who is able and willing to impart his knowledge, the horizon of the student widens. Actually, we find the practical classes extremely popular, the students often staying long past the nominal closing hour of the class in order to finish a job or the discussion that has arisen from it.—Yours, etc.,

George H. Rutland.

Wulfruna Street,
Wolverhampton.
November 1, 1937.

Forthcoming Events

NOVEMBER 8

Institute of Metals (Scottish Section):—Works visit to G. & J. Weir, Limited, Cathcart.

NOVEMBER 9.

Institute of Metals (Sheffield Section):—"Powder Metallurgy," Paper by J. C. Chaston, at Applied Science Department of the University, St. George's Square, Sheffield, at 7.30 p.m.

Institute of Metals (Swansea Section):—"Qualitative Analysis of Minute Inorganic Samples," Paper by Miss I. H. Hadfield, at Y.M.C.A., Swansea, at 6.30 p.m.

NOVEMBER 11

Institute of Metals (London Section):—"Training and Employment of Metallurgists," Paper by Prof. R. S. Hutton, at Royal School of Mines, South Kensington, at 8 p.m.

NOVEMBER 12

Manchester Association of Engineers:—"Work Analysis without a Stop Watch," Paper by E. Hijmans, at Engineers' Club, Albert Square, Manchester, at 7.15 p.m.

Institute of British Foundrymen

NOVEMBER 9.

Burnley Section:—"Cupola Practice in a Textile Engineering Works," Paper by J. Jackson, at Municipal College, Ormerod Road, Burnley, at 7.30 p.m.

NOVEMBER 13.

Scottish Branch:—"Impressions of Modern Foundry Practice," Paper by H. Lowe, and "Relation of Moisture to Principal Properties of Moulding Sands," by J. Dearden, at Royal Technical College, Glasgow, at 4 p.m.

West Riding of Yorkshire Branch:—Works visit to J. Blakeborough & Sons, Limited, Brighouse.

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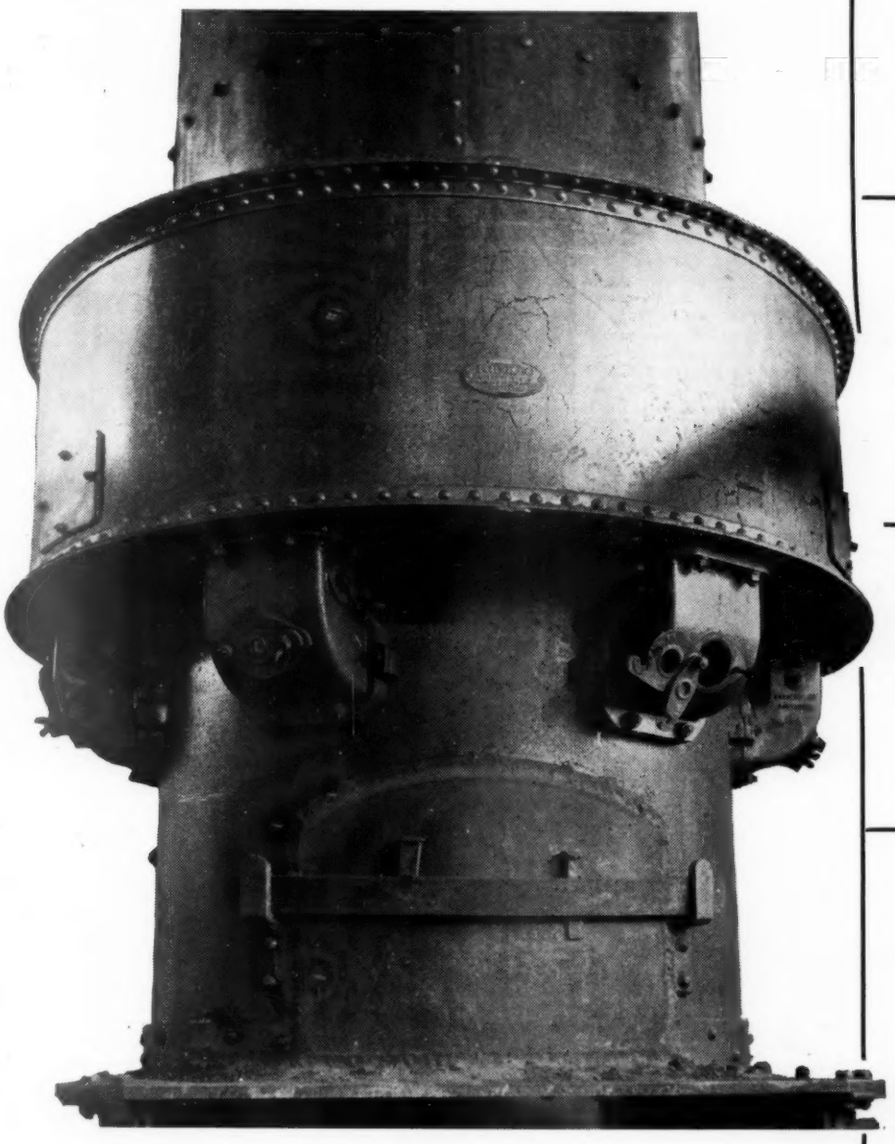

FIREBRICKS suitable for Cupola Linings

1—GLENBOIG

Manufactured from the famous Glenboig Fireclay, this firebrick has enjoyed a world wide reputation for almost a century

2—WHITE CARR

Low porosity is essential in the case of furnace linings subjected to abrasive forces and to slag action, and in this respect White Carr Firebricks have proved to be particularly valuable

3—DYKEHEAD

Since 1916 Dykehead bricks have been enjoying an ever increasing reputation for uniformity of fine quality

4—STOUR

Stour firebricks are capable of withstanding very high temperatures without melting or splitting and where sudden changes of temperature have to be contended with, are unsurpassed

Please address enquiries to the nearest Sales Office:

GENERAL REFRACTORIES LTD.

Telephone: *Sheffield* 31113 (6 *lines*) **GENEFAX HOUSE, SHEFFIELD, 10** *Telegrams:* *"Genefax Sheffield"*

LONDON OFFICE: Russell House, Adelphi, W.C.2. Telephone: Temple Bar 3511. Telegrams: "Genefax, Rand-London." (Mr. A. C. Turner).

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SWANSEA OFFICE: Metropole Chambers, Wind Street. Telephone: 3680. Telegrams: "Genefax, Swansea." (Mr. D. F. Hood-Williams).

MANCHESTER OFFICE: 9, Albert Square. Telephone: Blackfriars 6130 Telegrams: "Genefax, Manchester." (Mr. S. G. Throssell).

MIDDLESBROUGH OFFICE: Halifax Bldgs., Exchange Place, Telephone: Middlesbrough 3313. Telegrams: "Genefax, Middlesbrough." (Mr. J. A. Williams).

CARDIFF OFFICE: 17, Windsor Place, Telephone: 5796. Telegrams: "Genefax, Cardiff." (Mr. F. E. Rutter).

Raw Material Markets

The Foundry Pig-iron Producers' Association has decided to put into operation a loyalty rebate scheme similar to that brought into being some time ago by the hematite makers The new scheme became operative on November 1, and from that date the prices of foundry and forge pig-iron with a phosphoric content of not less than 0.75 per cent. were increased by 5s. per ton, subject to the terms of the rebate scheme.

With regard to prices of iron for next year, basic iron makers have intimated their intention to maintain current quotations for the first half of the year. No decision has been announced as to the level of prices of other grades of iron.

The 5s. increase in foundry grades as from November 1 is, of course, cancelled out by the loyalty rebate of a corresponding amount. The question of supplies of Continental iron is brought to the fore by the rebate scheme. Purchases of foreign iron have been a very welcome help during recent periods of stringency of supply. The position is a little easier now, but, presumably, if conditions become tight again consumers who purchase iron abroad to supplement their supplies will jeopardise their position under the rebate scheme. Some arrangement to meet the special circumstances would seem to be desirable until such time as the statistical position becomes regularised.

Pig-Iron

MIDDLESBROUGH. — Consumers of Cleveland foundry iron are still experiencing much difficulty in procuring adequate tonnages, as production is being confined almost entirely to the manufacture of steel-making irons. Substitutes in the form of Midland, French and Belgian irons are having to be used in many cases. The price of Cleveland foundry iron remains only nominal at 106s. for No. 3 grade delivered to Middlesbrough, subject to rebate. Users of hematite are more fortunately placed, and current requirements are generally being met. But little new business is accepted, as surplus material is rarely to be found in sufficient tonnages. With regard to next year's prices, an increase of as much as 20s. is envisaged in some quarters, but the official advance is likely to be rather less, although no indication has, as yet, been given.

LANCASHIRE. — Deliveries of pig-iron and hematite in this area are much more frequent and consist of heavier tonnages than they did a short time ago. It is still very difficult to obtain supplies of Scottish pig-iron. Consumers are not now placing much business abroad, and recent transactions have involved only small tonnages of American and Continental material. For delivery to users in the Lancashire price zone, offers of Derbyshire and Staffordshire brands of No. 3 foundry iron are on the basis of 114s., with Northants at 112s. 6d. and Derbyshire forge iron at 109s. or 111s., according to the class of user, subject to 5s. rebate. East Coast hematite is quoted at 130s. 6d., West Coast at 131s., and Scottish No. 3 at around 140s., delivered equal to Manchester.

MIDLANDS. — Easier conditions continue to prevail in this area, and deliveries are being despatched with greater regularity. Nevertheless, it is still almost impossible to build up stocks of any size, and consumers will not be satisfied until this position is alleviated. For delivery to Birmingham and Black Country stations, Northants No. 3 is now quoted at 108s. 6d., with Derbyshire, Lincolnshire and North Staffordshire No. 3 at 111s. Any business for 1938 is arranged so that makers will receive the price ruling at the date of despatch, but little has been done in this respect, as consumers prefer to await publication of the new quotations. Special irons continue to be actively taken up. Low- and medium-phosphorus grades are quoted between £6 5s. and £6 15s., while refined iron is at a minimum of £8 2s. 6d. The demand for hematite is strong, and steelworks remain heavy consumers. For delivery to the Midlands, East Coast No. 3 is quoted at £6 13s. 6d. and West Coast mixed numbers at £6 14s. 6d. per ton.

GLASGOW.—In this area consumers of pig-iron now find it easier to procure supplies, as a fair tonnage continues regularly to be imported. What will be the position in this respect with a rebate scheme in force remains to be seen. Basic iron also has been received from abroad in good quantities. No. 3 foundry iron is still quoted at 118s., f.o.t. furnaces, No. 3 Cleveland is at 109s. f.o.t. Falkirk and 112s. f.o.t. Glasgow, but these figures are purely nominal, as no supplies are available. Quotations for steel-making irons are 123s. for mixed numbers of hematite, 107s. 6d. for Scottish basic and 100s. for English and Indian basic, all less 5s. rebate, delivered steelworks here. Local steelworks remain very active, and their requirements of steel-making irons are large.

Coke

Conditions on the foundry-coke market remain very firm. It is possible to transact business over the whole of next year, but generally consumers are desirous of covering their winter requirements only. For delivery in Birmingham and district, best Durham foundry coke is quoted at 55s. 9d., with Welsh coke at from 55s. to 65s. per ton.

Steel

Conditions of great activity prevail in the steel industry and the producing works are taking advantage of the lull in new business to reduce the heavy accumulation of orders on their books. It is evident, however, that most of the steelworks will carry over the end of the year a very large tonnage of work for execution in 1938. The steelmakers are receiving sufficient hematite and basic iron to fill their current needs and appear to be less nervous regarding the future. Although tight conditions continue to rule in the semi-finished steel department, supplies are showing a tendency to expand. Increased imports are expected over the next few months, while production is being pressed to the utmost at the British works. The demand for practically all descriptions of finished steel material is unrelaxed, and, although the makers are not anxious to add to their commitments, a certain amount of business has been accepted for delivery over the first half of next year. Export business remains quiet, but the British works have considerable tonnages to deliver against existing contracts.

Scrap

Despite vigorous efforts to obtain additional supplies of steel scrap, merchants continue to experience considerable difficulty in satisfying the demand. New business is offered in plenty, but in existing circumstances only a limited amount can be accepted. Imports continue to arrive from the United States and the Continent. Iron scrap is more plentiful in several areas, and prices have weakened a little.

Metals

Copper.—This market has changed but little recently. While consumers have not shown much interest in the way of new business, specifications against existing contracts have been on a heavy scale. The domestic price in the United States has been further reduced and the present level is 11.75 cents per lb. delivered Connecticut Valley, but other producing concerns continue to quote 12 cents.

Speaking at the recent annual general meeting of the Rhokana Corporation, Sir Auckland C. Geddes, chairman, said that various causes had been ascribed for the high prices, not only of copper, but of other base metals, reached in the spring of the year, but making all allowances for the factor of speculation, which undoubtedly assisted in raising prices to their highest levels, the fact remained that the real consumption of copper outside the United States over the whole year had shown a substantial increase over the preceding year. Although the monthly rate of consumption at present was somewhat below the highest monthly figure for this calendar year, it still made a very satisfactory showing. The increased demand for copper during the year and the consequent increase in their production had caused considerable expansion in the scale of their operations at Nkana and Mindola.

Metal Exchange quotations were as follow :—

Cash.—Thursday, £43 10s. to £43 12s. 6d.; Friday, £43 3s. 9d. to £43 5s.; Monday, £42 17s. 6d. to £43; Tuesday, £41 13s. 9d. to £41 15s.; Wednesday, £41 5s. to £41 7s. 6d.

Three Months.—Thursday, £43 16s. 3d. to £43 17s. 6d.; Friday, £43 10s. to £43 11s. 3d.; Monday, £43 3s. 9d. to £43 5s.; Tuesday, £42 to £42 1s. 3d.; Wednesday, £41 11s. 3d. to £41 12s. 6d.

Tin.—Mr. W. H. Gartsen (Henry Rogers, Sons & Company) reports that the total visible supply of tin on October 31 amounted to 18,421 tons, as compared with 18,410 tons at the end of September. The carry-over in the Straits Settlements totalled 2,322 tons and 2,395 tons respectively, while the corresponding figures for the carry-over at the Arnhem (Holland) smelter were 1,085 tons and 1,227 tons. Thus, the world supply was 204 tons lower on the month, which created a big surprise in tin circles, as it had been anticipated that the October figures would reveal a substantial increase, and it was widely suggested that an increase of as much as 3,000 tons would result. It is now suggested that the position has been brought about by American buyers having been in the market for much greater tonnages than had been supposed.

Sir Harry S. Foster, chairman of United Tin Areas of Nigeria, Limited, speaking at the recent meeting of the company, said that the price of tin had been maintained throughout the financial year at such a satisfactory and stable level was due in large measure to the untiring efforts and far-sighted policy of those who were responsible for the introduction of restriction of output. The time limits fixed for the collapse of restriction by its opponents had long been passed. That the price had fluctuated rather wildly during the past few weeks could be ascribed mainly to the influence of the opponents of tin restriction, who successfully outvoted the continuance of the buffer pool, a measure by which the International Tin Committee retained in stock a proportion of the world's production, so that the powerful pool thus created immediately remedied any sudden increase in consumption by the delivery of spot tin or, alternatively, by the purchase of tin should the market, for any reason, be temporarily overstocked. The desirability of such a pool with the stability it ensured was obvious, and it was to be hoped that the recent heavy fall in the price of tin would have convinced independent critics of the necessity for its re-establishment.

Official quotations were as follow :—

Cash.—Thursday, £209 15s. to £210; Friday, £209 10s. to £209 15s.; Monday, £206 5s. to £206 10s.; Tuesday, £202 to £202 10s.; Wednesday, £199 10s. to £200.

Three Months.—Thursday, £209 15s. to £210; Friday, £209 10s. to £209 15s.; Monday, £206 5s. to £206 10s.; Tuesday, £202 to £202 10s.; Wednesday, £199 10s. to £200.

Spelter.—The undertone of this market remains sound, although outwardly an appearance of nervousness is given. Owing to the acute shortage of high-grade metal, many consumers have been compelled to accept supplies of g.o.b., which has become rather more plentiful of late. The price in the United States has further declined, and is now 5.75 cents per lb. East St. Louis. According to the American Bureau of Metal Statistics, world production of spelter in September totalled 151,400 tons, against 156,200 tons in the previous month.

Daily market prices :—

Ordinary.—Thursday, £17 6s. 3d.; Friday, £17; Monday, £16 12s. 6d.; Tuesday, £16 8s. 9d.; Wednesday, £16 6s. 3d.

Lead.—The American Bureau of Metal Statistics reports that world production of lead in September amounted to 156,400 short tons, against 158,400 tons in August. A fair tonnage has continued to change hands, and the outlook is satisfactory.

Day-to-day quotations :—

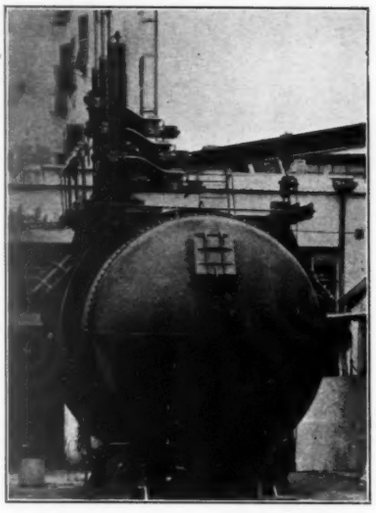
Soft Foreign (Prompt).—Thursday, £18 10s.; Friday, £18 6s. 3d.; Monday, £17 13s. 9d.; Tuesday, £17 5s.; Wednesday, £17 2s. 6d.

Scrap.—Consumers continue to remain aloof from the market and business is very quiet.

Approximate selling prices for old metal:—New aluminium cuttings, £82; rolled, £67; cast, £40; foil, £94 to £98. Copper, £39 to £43; braziery, £37. Brass (clean), £27 to £30. Zinc, £10. Lead, £17. Gunmetal, £39 to £40.

Ferro-Alloy Prices

The following ferro-alloy prices have been announced for next year:—Ferro-tungsten, 80/85 per cent., 8s. 6d. per lb. of tungsten contained for January/March delivery (a reduction of 9d. from current prices); tungsten metal powder, 98/99 per cent., 8s. 7½d. per lb. of alloy for January/March delivery (a reduction of 10½d.); ferro-molybdenum, 70/75 per cent. Mn, carbon free, 5s. per lb. of Mo contained for January/June delivery (an increase of 3d.).



METALECTRIC MIXER

For Iron and Steel Alloys . . .

Specialists in Electric Furnaces for melting and all classes of heat treatment, including hardening, tempering, bright annealing, etc.—Special plant for any continuous heat treatment—Industrial temperature indicating, controlling and recording instruments.

3-phase electric mixer
20 ton capacity.

Metalectric-Russ Induction Furnaces for melting non-ferrous metals including aluminium and light metal alloys.

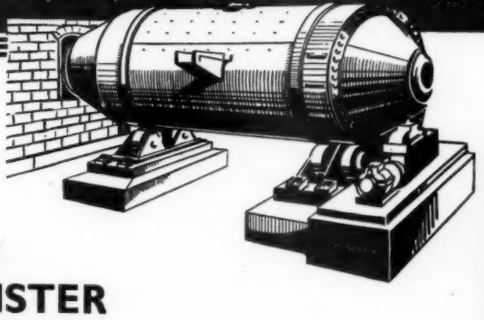
METALECTRIC TAGLIAFERRI FURNACES FOR IRON, STEEL, FERRO-ALLOYS AND CALCIUM CARBIDE MANUFACTURE.

WRITE NOW FOR PARTICULARS AND LEAFLETS

METALECTRIC FURNACES LTD.
SMETHWICK • BIRMINGHAM

DESCRIPTIONS & SPECIFICATIONS OF ELECTRIC FURNACES AVAILABLE TO MEET THE REQUIREMENTS OF THE INDUSTRY

LININGS.



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ROTARY FURNACES
STEEL CONVERTORS
CUPOLAS AND TILTERS

- *BLACK SEAM* **GANISTER** *PATCHING AND MONOLITHIC LININGS.*
- **RAM YOUR FURNACE FOR ECONOMY.**

EXPERT SUPERVISION FREE.

Write for details . . . . .

THE MIDLAND MONOLITHIC FURNACE LINING CO., LTD.,

TELEPHONE No. 65564.

40, Humberstone Road, Leicester.

RAW MATERIALS—PRICE LIST

(Wednesday, November 3, 1937)

COPPER

	£ s. d.
Standard cash	41 5 0
Three months	41 11 3
Electrolytic	46 0 0
Tough	47 5 0
Best selected	47 15 0
Sheets	80 0 0
India	58 15 0
Wire bars	49 0 0
Ingot bars	49 0 0
H.C. Wire rods	52 10 0
Off. av. cash, Oct.	45 8 9
Do., 3 mths., Oct.	45 12 11
Do., Sttlmnt., Oct.	45 8 9½
Do., Electro, Oct.	51 9 9½
Do., B.S., Oct.	51 17 6
Do., Wire bars, Oct.	52 7 1½
Solid drawn tubes	13d.
Brazed tubes	13d.
Wire	8¾d.

BRASS

Solid drawn tubes	11½d.
Brazed tubes	13½d.
Rods, drawn	9½d.
Rods, extd. or rlld.	7d.
Sheets to 10 w.g.	9d.
Wire	8¾d.
Rolled metal	8½d.
Yellow metal rods	7d.

TIN

Standard cash	199 10 0
Three months	199 10 0
English	199 10 0
Bars	201 10 0
Straits	203 0 0
Eastern	206 17 6
Banca (nom.)	—
Off. av. cash, Oct.	224 0 11¾
Do., 3 mths., Oct.	223 9 10½
Do., Sttlmt., Oct.	224 1 10½

SPELTER

Ordinary	16 6 3
Remelted	14 10 0
Hard	14 0 0
Electro, 99.9	19 18 9
English	17 15 0
India	15 15 0
Zinc dust	23 10 0
Zinc ashes	6 0 0
Off. aver., Oct.	17 16 9½
Aver., spot, Oct.	17 14 5¾

LEAD

Soft foreign, ppt.	17 2 6
Empire (nom.)	18 1 3
English	19 5 0
Off. aver., Oct.	18 5 9½
Aver. spot, Oct.	18 5 2½

ALUMINIUM

Ingots	£100 to £105
Wire	1/3 to 1/4 lb.
Sheet and foil	1/2 to 1/4 lb.

ZINC SHEETS, &c.

Zinc sheets, English	30 10 0 to 31 0 0
Do., V.M. ex-whse.	30 10 0 to 31 0 0
Rods	25 0 0

ANTIMONY

English	92 10 0 to 93 10 0
Chinese, ex-whse. (nom.)	80 0 0
Crude, c.i.f.	47 0 0

QUICKSILVER

Quicksilver	13 0 3

FERRO-ALLOYS AND STEEL-MAKING METALS

Ferro-silicon—	
25%	14 10 0
45/50%	12 0 0
75%	17 0 0
Ferro-vanadium	
35/50%	12/8 lb. Va.
Ferro-molybdenum—	
70/75% carbon-free	4/9 lb. Mo.
Ferro-titanium—	
20/25% carbon-free	9d. lb.
Ferro-phosphorus, 20/25%	£21 to £22
Ferro-tungsten—	
80/85%	9/3 lb.
Tungsten metal powder—	
98/99%	9/6 lb.
Ferro-chrome—	
2/4% car.	34 15 0
4/6% car.	24 5 0
6/8% car.	24 0 0
8/10% car.	24 0 0
Ferro-chrome—	
Max. 2% car.	36 0 0
Max. 1% car.	38 5 0
Max. 0.5% car.	41 0 0
70% carbon-free	10d. lb.
Nickel—99.5/100%	£180 to £185
"F" nickel shot	£165 0 0
Ferro-cobalt, 98/99%	8/6 to 8/9 lb.
Metallic chromium—	
96/98%	2/5 lb.
Ferro-manganese—	
76/80% loose	£18 15 0 to 19 5 0
76/80% packed	£19 15 0 to 20 5 0
76/80% export	£22 0 0
Metallic manganese—	
94/96% carbon-free	1/3 lb.

Per ton unless otherwise stated, basis 2-ton lots.

HIGH-SPEED TOOL STEEL

Finished bars, 14% tungsten	3s. 10d.
Finished bars, 18% tungsten	5s. 0d.

Per lb. d/d buyers' works.

Extras—

Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under ½ in. to ¼ in.	3d. lb.
Do., under ¼ in. to $\frac{7}{16}$ in.	1/- lb.
Flats, ½ in. × ¼ in. to under 1 in. × ⅛ in.	3d. lb.
Do., under ½ in. × ¼ in.	1/- lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra.

SCRAP

South Wales (West)	£ s. d.	£ s. d.
Heavy steel, best	3 8 6	to 3 11 0
Mixed iron and steel	3 6	0 to 3 8 6
Heavy cast iron	3 8 6	to 3 11 0
Good machinery		3 17 6
Cleveland—		
Heavy steel, best	3 7	0 to 3 9 6
Steel turnings		2 15 0
Heavy cast iron		4 5 0
Heavy machinery		4 10 0
Midlands—		
Short heavy steel		4 0 0
Light cast-iron scrap		3 2 6
Heavy wrought iron	4 0	0 to 4 5 0
Steel turnings	2 5	6 to 2 8 0
Scotland—		
Heavy steel, best	3 5	0 to 3 7 6
Ordinary cast iron	4 7	6 to 4 10 0
Cast-iron borings	2 0	0 to 2 2 6
Wrot-iron piling		4 17 6
Heavy machinery	4 15	0 to 4 16 3

London—Merchants' buying prices, delivered yard.

Copper (clean)	37 0 0
Brass	25 0 0
Lead (less usual draft)	15 0 0
Tea lead	12 0 0
Zinc	10 0 0
New aluminium cuttings	71 0 0
Braziery copper	33 0 0
Gunmetal	37 0 0
Hollow pewter	140 0 0
Shaped black pewter	100 0 0

PIG-IRON

N.E. Coast (d/d Tees-side area)—	
Foundry No. 1	108/6*
,, No. 3	106/-*
,, No. 4	105/-*
Forge No. 4	105/-*
Hematite No. 1	123/-*
Hematite M/Nos.	122/6*
N.W. Coast—	
Hem. M/Nos. d/d Glas.	123/-*
,, d/d Birm.	134/6*
Malleable iron d/d Birm.	160/-
Midlands (d/d Birmingham dist.)—	
Staffs No. 4 forge	108/-*
,, No. 3 fdry.	111/-*
Northants forge	105/6*
,, fdry. No. 3	108/6*
,, fdry. No. 1	111/6*
Derbyshire forge	108/-*
,, fdry. No. 3	111/-*
,, fdry. No. 1	114/-*
Scotland—	
Foundry, No. 1, f.o.t.	120/6
,, No. 3, f.o.t.	118/-
Cleveland No. 3, Glasgow	112/-*
,, ,, Falkirk	109/-*
Scottish hem. M/Nos. d/d	123/-*
Sheffield (d/d district)—	
Derby forge	105/6*
,, fdry. No. 3	108/6*
Lincs forge	105/6*
,, fdry. No. 3	108/6*
W.C. hematite	128/6*
Lancashire (d/d eq. Man.)—	
Derby fdry, No. 3	114/-*
Staffs fdry. No. 3	114/-*
Northants fdry. No. 3	112/6*
Cleveland fdry. No. 3	114/6*
Glengarnock, No. 3	140/-
Clyde, No. 3	140/-
Monkland, No. 3	140/-
Summerlee, No. 3	140/-
Eglinton, No. 3	140/-
Gartsherrie, No. 3	140/-
Shotts, No. 3	140/-

* Subject to a rebate of 5s. per ton under certain conditions.

FINISHED IRON AND STEEL

Usual district deliveries.

[A rebate of 15/- per ton for steel sections, plates and joists is obtainable in the home trade under certain conditions.]

Iron—	£ s. d.	£ s. d.
Bars (cr.)	13 5 0	to 13 15 0
Nut and bolt iron	11 12 6	to 12 2 6
Hoops		14 2 6
Marked bars (Staffs) f.o.t.		15 15 0
Gas strip		14 2 6
Bolts and nuts, ¾ in. × 4 in.		17 10 0 and up.
Steel—		
Plates, ship, etc.	11 8	0 to 11 10 6
Boiler plts.	11 18	0 to 12 0 6
Chequer plts.		13 0 6
Angles		11 0 6
Tees		12 0 6
Joists		11 0 6
Rounds and squares, 3 in. to 5½ in.		12 0 6
Rounds under 3 in. to ⅜ in. (Untested)		11 9 0
Flats—8 in. wide and over		11 5 6
,, under 8 in. and over 5 in.		11 10 6
Rails, heavy		10 2 6
Fishplates		14 2 6
Hoops (Staffs)		12 4 0
Black sheets, 24g. (4-t. lots)		15 15 0
Galv. cor. shts. (,,)		19 10 0
Galv. flat shts. (,,)		20 0 0
Galv. fencing wire, 8g. plain		20 5 0
Billets, soft, 100-ton lots		7 17 6
Sheet bars		7 15 0
Tin bars		7 15 0

PHOSPHOR BRONZE

	Per lb. basis
Strip	11½d.
Sheet to 10 w.g.	12d.
Wire	13¾d.
Rods	14½d.
Tubes	18¾d.
Castings	16d.

Delivery 3 cwt. free.
10% phos. cop. £33 above B.S.
15% phos. cop. £38 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. CLIFFORD & SON, LIMITED.

NICKEL SILVER, &c.

	Per lb.
Ingots for raising	8d. to 1/2
Rolled—	
To 9 in. wide	1/2 to 1/8
To 12 in. wide	1/2½ to 1/8½
To 15 in. wide	1/2½ to 1/8½
To 18 in. wide	1/3 to 1/9
To 21 in. wide	1/3½ to 1/9½
To 25 in. wide	1/4 to 1/10
Ingots for spoons and forks	8d. to 1/1½
Ingots rolled to spoon size	11d. to 1/7½
Wire round—	
to 10g.	1/5½ to 2/0½

with extras according to gauge.
Special 5ths quality turning rods in straight lengths, 1/4½ upwards.

AMERICAN IRON AND STEEL

At Pittsburgh unless otherwise stated.

	Dols.
No. 2 foundry, Phila.	25.76
No. 2 foundry, Valley	24.00
No. 2 foundry, Birm.	20.38
Basic, Valley	23.50
Malleable, Valley	24.00
Grey forge, Valley	23.50
Ferro-mang. 80%, seaboard	102.50
O.-h. rails, h'y, at mill	42.50
Billets	37.00
Sheet bars	37.00
Wire rods	47.00
	Cents.
Iron bars, Chicago	2.40
Steel bars	2.45
Tank plates	2.25
Beams, etc.	2.25
Skelp, grooved steel	2.10
Steel hoops	2.40
Sheets, black, No. 24	3.15
Sheets, galv., No. 24	3.80
Wire nails	2.75
Plain wire	2.90
Barbed wire, galv.	3.40
Tinplates, 100-lb. box	$5.35

COKE (at ovens)

Welsh foundry	42/6
,, furnace	37/6
Durham foundry	38/6
,, furnace	37/6
Scottish foundry	42/6
,, furnace	40/-

TINPLATES

f.o.b. Bristol Channel ports.

I.C. cokes	20×14	per box	23/6 to 24/6
,,	28×20	,,	47/- to 49/-
,,	20×10	,,	34/6 to 35/-
,,	18¾×14	,,	24/6 to 25/-
C.W.	20×14	,,	21/6 to 22/-
,,	28×20	,,	43/- to 44/-
,,	20×10	,,	31/- to 31/6
,,	18¾×14	,,	22/- to 22/6

SWEDISH CHARCOAL IRON & STEEL

Pig-iron	£12 0 0	to £13 0 0	
Bars-hammered, basis	£20 0 0	to £22 0 0	
Bars and nail-rods, rolled, basis	£19 0 0	to £20 0 0	
Blooms	£18 0 0	to £19 0 0	
Keg steel	£30 0 0	to £35 0 0	
Faggot steel	£20 0 0	to £25 0 0	
Bars and rods dead soft st'l	£19 0 0	to £20 0 0	

All per English ton, f.o.b. Gothenburg.
[Subject to an exchange basis of Kr. 19.39 to £1.]

DAILY FLUCTUATIONS

Standard Copper (cash)

			£	s.	d.		
Oct.	28	..	43	10	0	inc.	21/3
,,	29	..	43	3	9	dec.	6/3
Nov.	1	..	42	17	6	,,	6/3
,,	2	..	41	13	9	,,	23/9
,,	3	..	41	5	0	,,	8/9

Electrolytic Copper

			£	s.	d.		
Oct.	28	..	48	0	0	inc.	10/-
,,	29	..	48	0	0	No	change
Nov.	1	..	48	10	0	inc.	10/-
,,	2	..	47	0	0	dec.	30/-
,,	3	..	46	0	0	,,	20/-

Standard Tin (cash)

			£	s.	d.		
Oct.	28	..	209	15	0	inc.	75/-
,,	29	..	209	10	0	dec.	5/-
Nov.	1	..	206	5	0	,,	65/-
,,	2	..	202	0	0	,,	85/-
,,	3	..	199	10	0	,,	50/-

Tin (English ingots)

			£	s.	d.		
Oct.	28	..	209	15	0	inc.	75/-
,,	29	..	209	10	0	dec.	5/-
Nov.	1	..	206	5	0	,,	65/-
,,	2	..	202	0	0	,,	85/-
,,	3	..	199	10	0	,,	50/-

Spelter (ordinary)

			£	s.	d.		
Oct.	28	..	17	6	3	inc.	10/-
,,	29	..	17	0	0	dec.	6/3
Nov.	1	..	16	12	6	,,	7/6
,,	2	..	16	8	9	,,	3/9
,,	3	..	16	6	3	,,	2/6

Spelter (Electro, 99.9 per cent.)

			£	s.	d.		
Oct.	28	..	21	0	0	inc.	10/-
,,	29	..	20	11	3	dec.	8/9
Nov.	1	..	20	6	3	,,	5/-
,,	2	..	20	1	3	,,	5/-
,,	3	..	19	18	9	,,	2/6

Lead (soft foreign, prompt)

			£	s.	d.		
Oct.	28	..	18	10	0	inc.	13/9
,,	29	..	18	6	3	dec.	3/9
Nov.	1	..	17	13	9	,,	12/6
,,	2	..	17	5	0	,,	8/9
,,	3	..	17	2	6	,,	2/6

Lead (English)

			£	s.	d.		
Oct.	28	..	20	10	0	inc.	15/-
,,	29	..	20	10	0	No	change
Nov.	1	..	19	15	0	dec.	15/-
,,	2	..	19	5	0	,,	10/-
,,	3	..	19	5	0	No	change

AVERAGE MONTHLY PRICES OF STEEL RAILS

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly average
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1922	9 10 0	9 10 0	9 10 0	9 10 0	9 10 0	9 10 0	9 10 0	9 0 0	8 15 0	8 15 0	8 15 0	8 15 0	9 4 2
1923	8 17 6	9 2 0	10 5 0	10 10 0	10 10 0	10 10 0	9 15 0	9 0 0	8 15 0	8 15 0	8 19 0	9 5 0	9 9 10
1924	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 2 6	9 0 0	9 0 0	9 0 0	9 0 0	9 0 0	9 0 0	9 2 3½
1925	9 0 0	9 0 0	9 0 0	9 0 0	8 15 0	8 10 7½	8 10 0	8 10 0	8 10 0	8 4 0	8 0 0	8 0 0	8 11 7½
1926	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 7 6	8 10 0	8 10 0	8 10 0	8 10 0	8 5 11½
1927	8 10 0	8 10 0	8 10 0	8 2 6	8 2 6	8 2 6	8 2 6	8 2 6	8 2 6	8 3 0	8 5 0	8 5 0	8 4 10
1928	8 5 0	8 5 0	8 5 0	8 5 9	8 6 3	8 6 3	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 7 9½
1929	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0
1930	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0
1931	8 9 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 8
1932	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6
1933	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6
1934	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6
1935	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6
1936	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6
1937	8 7 6	8 7 6	8 7 6	8 7 6	10 2 6	10 2 6	10 2 6	10 2 6	10 2 6	10 2 6	—	—	—

AVERAGE MONTHLY PRICES OF EAST COAST HEMATITE MIXED NUMBERS AT MIDDLESBROUGH

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average
	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
1921	240 0	220 0	180 0	180 0	180 0	160 0	160 0	160 0	137 0	127 6	117 6	104 6	162 2
1922	97 6	91 7½	100 0	98 6	97 1½	94 7	93 6	90 9	89 7	91 10½	93 0	93 2	94 5½
1923	94 6	104 9	122 0	126 10½	122 0	115 3	107 0	98 8½	98 10½	99 1½	100 6½	102 3	107 10½
1924	102 4½	101 3	99 7½	99 0	98 9½	97 4½	95 3½	93 1½	90 7½	88 0	88 4½	88 6	95 2½
1925	87 5	85 9	84 7½	82 6	80 10½	79 3	77 1½	75 7½	75 0	74 3½	74 9	76 0	79 5½
1926	77 3	77 9	77 3½	76 3	77 4½	78 0	79 8½	81 9	83 4½	87 7½	92 6	90 5½	81 7½
1927	90 0	90 0	86 3½	83 1½	80 6	78 0	76 6	75 4½	75 0	72 9	71 9	71 1½	79 2½
1928	69 7½	69 7½	69 9	70 0	70 0	69 3	68 7½	69 2	70 0	70 0	70 3	71 0	69 9½
1929	71 6	72 0	73 6	74 0	74 0	74 1½	74 9	75 6	76 1½	76 8½	78 1½	79 0	74 11½
1930	78 2½	78 0	76 9	75 0	74 0	72 7½	71 0	71 0	71 0	71 0	70 10½	70 4½	73 3½
1931	70 0	69 0	68 0	66 8½	65 1½	63 4½	62 9	61 1½	65 0	65 0	65 0	65 0	65 6
1932	64 10	64 3	63 6	63 6	63 6	62 7½	62 0	60 6	60 0	59 3	59 0	59 0	61 10
1933	59 0	59 0	59 0	59 0	59 0	59 0	59 0	59 0	59 3	60 7½	62 6	62 6	59 8½
1934*	62 6	65 0	67 6	67 6	67 6	67 6	67 6	67 6	68 0	68 6	68 6	68 6	67 2
1935*	68 6	68 6	68 6	68 6	68 6	68 6	69 7½	70 6	70 6	70 6	70 6	70 6	69 5½
1936*	70 6	75 3	76 6	76 6	77 4	80 0	85 0	85 0	85 0	85 0	85 0	85 0	80 6
1937*	97 6	97 6	97 6	122 6	122 6	122 6	122 6	122 6	122 6	122 6	—	—	—

* Since March, 1934, delivered works; previously f.o.t. furnaces. NOTE.—Prices of hematite have since July 1, 1936, been subject to a rebate of 5s. under certain conditions.

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SITUATIONS VACANT AND WANTED—*Contd.*

EMPLOYMENT REGISTER.

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Correspondence should be addressed to the General Secretary, Institute of British Foundrymen, St. John Street Chambers, Deansgate, Manchester, from whom full particulars can be obtained of this service.

Any employer wishing to communicate with a candidate should write to the General Secretary, quoting identification number.

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Steel Tank, 12 ft. by 12 ft. by 6 ft.
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